ROADS and STREETS

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HALBERT P. GILLETTE, President and Editor
R. W. HUME, Vice-President
E. S. GILLETTE, Secretary
C. T. MURRAY, Managing Editor
FREDERIC KAMMANN II, Advertising Manager

Cleveland Office, 621 Hippodrome Bldg.: E. C. KELLY, Manager
New York Office, 441 Lexington Avenue: ERWIN T. EYLER, Eastern Manager

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Some Early History of Federal and State Aid Contrasted with Present Appropriations

About 20 years ago the first federal aid bill for road construction was drafted, and a small group of men went to Washington to urge its passage. The editor of this magazine was one of that group. The bill was not favorably reported by the house committee that investigated the matter, but the senate committee made a favorable report. Encouraged by this latter action, the proponents of the bill kept diligently at work and ultimately had the satisfaction of seeing the bill become a law.

It is interesting to record that the only editorial support that the bill received from the technical press was the support given by this magazine. In fact "Engineering News" vigorously opposed the bill, calling it a paternalistic measure. The "News" also opposed state aid laws for the same reason. "Good Roads" opposed the bill. "Engineering Record" lent it no support. The daily papers were lukewarm where they were not actually hostile.

We not only sent our editorial articles to many editors of daily papers, but wrote them personal letters replying to their arguments, giving facts and reasons supporting the contention that the federal government should appropriate money not merely to aid the states but to arouse all the states to the economic necessity of engaging extensively in road construction. Remember that 20 years ago few states were engaged in road construction, and even those few were appropriating miserably small sums of money. The richest state in the union started its state aid program of road building with an appropriation of $50,000 for the year 1900! Not a very auspicious beginning, but it was at least a beginning.

So level headed a man as Ira O. Baker, professor of highway engineering in the university of Illinois, was opposed to both state and federal aid, insisting that road work should be a local matter like street work. He enlisted a large following, including many farmers in his own state and other states. Farmers at that time were particularly susceptible to any argument against taxation for purposes of improvement, and particularly blind to the enormous mud tax that made hauling in many places almost impossible for nearly half the year.

So, between those who talked "paternalism and the pork barrel" and those who talked "higher taxes," the state aid had hard sledding, and federal aid scarcely sledded at all—at first.

For many years congress has seemed fairly liberal in its appropriations for federal aid in road building. The bill just passed and signed by the president provides $75,000,000 a year for two years, as aid to the states, plus $7,500,000 annually for forest roads and trails. This seems like a large sum, but it is really miserly when we consider the transportation needs and the vast wealth of America.

The annual income of the American people is about 75 billion dollars. Hence an appropriation of 75 million dollars is one-thousandth part of the total income. But, it will be replied, the states, counties, townships and road districts are spending a billion a year on roads. Surely that is liberal enough. Let us see.

According to the Bureau of Industrial Technology, Americans are spending 14 billions annually on their motor car bills. Although that estimate is grossly in error, still the true total is sufficiently great to indicate the inadequacy of the billion dollar expenditure for

road construction and maintenance. We know that about 25 per cent of state road funds go for maintenance (see "Roads and Streets" for April); and if half the county and township funds are similarly spent, then only 65 per cent of the billion dollars is spent for road improvement. Even if we add in all street improvement (the expenditure for which no one knows closely), the total spent for road and street construction falls short of a billion dollars annually, or less than $50 for each motor vehicle.

The small percentage of roads thus far surfaced with gravel or better material, the great congestion on many highways, the enormous cost of tire renewals (fully half of which is ascribable to poor roads), the rapid increase in the number of motor vehicles—all indicate clearly the inadequacy of a billion dollar road bill. Fully twice that sum should be spent annually on highway improvements.

However, we have made some progress since the day, only a generation ago, that a New York legislature reluctantly voted $50,000 for road improvement.

A Grossly Erroneous Estimate of America's Annual "Automobile Bill"

"Gone crazy with figures" is unfortunately true of many writers who eat more statistics than they can digest. One of the recent examples of figuritis that has arrested our attention is that of the "authority" for the data published by the Bureau of Industrial Technology. He estimates that "America's automobile bill, including cost of cars, insurance, upkeep, gasoline and numerous other items of expense, totals more than 14 billion dollars annually." Had this "authority" known that this is 20 per cent of the entire income of the American people, he might have been prompted to check his estimate. Here is his bill:

New cars and accessories	$3,750,000,000
Depreciation	2,500,000,000
Upkeep and repairs	2,000,000,000
Gasoline	1,200,000,000
Oil	300,000,000
Tires	618,000,000
Interest on investment	500,000,000
Taxes	625,000,000
Insurance	300,000,000
Total	$11,798,000,000
Garages	900,000,000
Drivers' wages	1,600,000,000
Grand total	$14,298,000,000

During 1925 there were nearly 20 million motor vehicles registered in America of which about 17½ millions were automobiles and 2½ millions were trucks. About 4,325,000 motor vehicles were produced in America in 1925, of which about 300,000 were exported. Since there was a gain of about 2,400,000 in registration in 1925 over 1924, it appears that about 1,600,000 motor vehicles must have been scrapped, which is not quite 10 per cent of the total that were registered in 1924. This would indicate an average life nearer 10 years than the commonly accepted estimates of 5 to 7 year life. In any event, the cost of buying the 4,000,000 new motor vehicles in 1925 includes the cost of depreciation on the old vehicles that were scrapped. Hence the second item, of $2,500,000,000 for depreciation, in the above given table is completely covered by the first item, and should be eliminated from the table.

The average retail price of new automobiles in 1925 is estimated at $1,000 by the "authority" who compiled the above given table; but another authority puts it at $866 for automobiles and $1350 for trucks, which, in view of the reported wholesale value seems more reliable. If so, about $500,000,000 should be taken from the first item in the above given table.

As far as we can learn, there are no reliable estimates of the cost of upkeep and repairs. Unless great care is taken in compiling figures on repairs, depreciation (or the cost of replacing an entire machine) will creep into many of the repair figures. It will be seen that in the above table "repairs" are estimated to be four times the "interest" charge; hence if the interest was figured at 5 per cent, "repairs" must have been figured at about 20 per cent. It amounts to about $150 per year per automobile. Any one is at liberty to guess how near right this is. It seems very liberal.

About 7½ billion gallons of gasoline were used by motor vehicles in 1925. Hence the tabulated estimate of the cost of gasoline appears reasonable.

About 56 million automobile and truck tires were produced, having a value of nearly 900 million dollars. This indicates that the tabulated estimate is a conservative one for automobiles only.

The "interest" estimate also seems conservative, but we can't say as much for the estimate of "taxes." Federal excise taxes were nearly 127 million dollars, but these are included in the retail price of the machines. Gasoline taxes, totaling 146 million dollars, are included in the price of the gasoline. Registration fees totaled 260 millions, and since relatively little is collected in personal property taxes on automobiles, it is approximately correct to say that registration fees constitute almost the entire "tax" item. Hence the

tabulated estimate above given is 360 millions too high.

We have no published statistics as to insurance, garage rental and drivers' wages, and we suspect that the "authority" back of the tabulated estimates had little more. He has estimated nearly $60 a year per automobile for "garage" expense and $20 for insurance. This, we believe, is several fold more than the actual cost. Drivers' wages is estimated by him at nearly $100 per automobile. Guess to suit your taste.

We believe that the tabulated total of nearly 12 billion dollars, exclusive of garage rental and drivers' wages, exceeds the actual cost by about 4½ billion dollars. Even so the total is enormous, being about 10 per cent of the entire income of the American people. Probably nearly 8 billions of dollars are expended annually for the "automobile bill" including garage rental. This is about eight times the total expenditure road construction and maintenance, which indicates very clearly that highway improvement expenditures are falling behind the needs of the times.

Impact in Highway Bridges

Editorial in the Canadian Engineer

Although a great deal of experimental work has been done in the determination of impact for railway bridges, a relatively small amount of attention has, until recently, been given to the measurement of impact in highway bridges. Useful information in this field was, however, obtained by Professor F. O. Dufour, of the University of Illinois, and presented in the Journal of the Western Society of Engineers for 1913, and, upon his results, the decision of the State of Illinois to neglect impact in bridges having reinforced concrete floors was based.

A more extensive investigation of the subject is the co-operative study that has been carried on since 1922 under the asupices of the United States Bureau of Public Roads, the Iowa State Highway Commission, and the Engineering Experiment Station of Iowa State College, the results of which are presented by Professors A. H. Fuller and Robert Caughey in a bulletin of the Engineering Experiment Station. This work has progressed sufficiently far to enable one to draw useful conclusions with regard to impact in floors of highway bridges, if not in the trusses. Speaking broadly, it may be stated that for a truck loaded to give approximately the proportions of front and rear axle loads now generally specified in highway bridge specifications, and traveling at a speed of twelve miles an hour, the impact increment of stress in the stringers and floor beams under smooth concrete floors and stressed well toward the allowable limits, has been found to be below 15 per cent. When the wheels of the truck ran over 1 by 2-in. obstructions, the percentage was about 50 per cent. For 2 by 4-in. obstructions the percentage approached 100 per cent. It is not practicable to make a general statement with respect to the impact in the floor system of timber floored spans, as it varies widely with the conditions of the individual floor.

Hitherto, no particular attention has been paid to the relation between the amount of load that is cushioned by springs and the amount not so cushioned. It was found in the investigation mentioned that the impact is due very largely to the unsprung weight of the truck. Thus, where the unsprung weight is only 24 per cent of the total weight, the impact observed in the stringers of a typical span in running a truck at a speed of eight miles per hour over a 1 by 2-in. obstruction, was about 35 per cent, while with a ratio of unsprung to total weight amounting to 60 per cent, the impact under the conditions already mentioned was about 147 per cent. It is therefore necessary, if one is to estimate impact with any precision, to know beforehand the ratio of unsprung to total weight for the truck or for the axle producing the maximum stress.

While impact investigations conducted prior to the one under consideration were carried out on the usual lines of measuring the stress in a member under static loading and in the same member under the load then moving, in the investigation by Professors Fuller and Caughey, a further effort was made to apply to the problem the information already obtained by the United States Bureau of Public Roads with respect to the blows of wheels on pavements. Highway engineers are familiar with the valuable work done by this bureau in establishing the magnitude of the dynamic force created by a wheel passing over a given obstruction. In the present impact study it was found possible to relate such blows to the resulting stresses in the members of a bridge. This relation indicates that between the point of application of the blow and the member in which the stress is sought, there is a great deal of cushioning. For example, if due to a wheel passing over an obstruction the dynamic force of the blow struck five times as great as the weight of the wheel, the stress in a stringer under a concrete floor slab would not be five times that arising from the imposition of a static load equal to the dynamic force of the blow, but would be about 51 per cent of five times as great, that is, about 2.55 times as great.

Indications so far obtained in the investigation, point to considerable impact stresses in

truss members, but the authors of the bulletin believe that these results are not at all representative under present conditions and not suitable as a basis for design Futher work should be done with heavier loads and loads covering a greater portion of the structure before impact data can be secured that will be of significant value in the design of trusses.

In view of the results so far obtained in the investigation, the impact allowance of 30 per cent applicable to stresses produced by motor truck loads in the highway bridge specification of the Canadian Engineering Standards Association appears reasonable. While it is possible that trucks may run over obstructions as high as one or two inches on a bridge, this circumstance would be infrequent and the factor of safety commonly maintained in design would well provide for such a contingency.

$150,000,000 More for Federal Aid

Congress on June 15 gave its final approval to the bill appropriating $150,000,000 for Federal aid road work. Through appropriations already passed for the fiscal year beginning July 1 and the measure agreed to by the House, Congress now has allowed an annual contribution of $75,000,000 for the next two years to help make improved highways a reality. This money will be matched dollar for dollar by the various states for building highways included in the $10,000,000,000 Federal aid state highway system of roads. Approximately 200,000 miles of highways are being or will be improved under the program. Department of Agriculture officials and the chief of the Bureau of Roads, Thomas M. MacDonald, immediately prepared to carry forward with renewed vigor the huge program of road construction. Passages of the legislation should enable the government and the several states to complete more than 60 per cent of the program of planned improvement by Jan. 1, 1930. It undoubtedly will make possible the early completion of at least one and possibly two paved transcontinental highways.

22,500 Killed by Automobiles in 1925

Automobile fatalities in the United States for 1925 totaled 22,500, an increase of approximately 2,200 over 1924, according to the report of the National Bureau of Casualty and Surety Underwriters made public June 13. The study shows that automobile fatalities in 147 cities, including collisions with street cars and railroad trains, increased from 17,600 in 1924 to 18,200 in 1925. Fatal automobile grade crossing accidents mounted from 1,688 in 1924 to 1,784 in 1925. The automobile death rate per 100,000 is shown by the report to have increased from 14.9 in 1923 to 15.7 in 1924 and to 17.2 in 1925. The increase from 1923 to 1924, therefore, was five per cent, while the increase from 1924 to 1925 was nearly ten per cent. From this it is deduced that fatal automobile accidents not only are increasing in number but the rate at which they are increasing also is rising. Registration of cars, the study shows, increased from 17,591,981 in 1924 to 19,954,347 in 1925. Fatality rates on the basis of registration have been decreasing for several years, but the rate for 1925 was practically the same as that for 1924.

Road and Street Contracts Awarded During the Last 77 Months

The accompanying table, compiled from statistics in the Engineering News Record, shows two outstanding facts: First, that highway contracts awarded during the last half of each year have averaged only 25 per cent less in volume than those awarded during the first half; second, that there is not a month in the year without a very large volume of road and street contracts awarded.

ROAD AND STREET CONTRACTS EXCEEDING $25,000 IN SIZE

	1920	1921	1922	1923	1924	1925	1926
January	$ 12,204,000	$ 11,598,000	$ 14,424,000	$ 21,691,000	$ 16,972,000	$ 22,720,000	$ 19,989,000
February	21,334,000	12,049,000	9,052,000	18,781,000	19,214,000	20,104,000	12,189,000
March	26,221,000	25,880,000	39,669,000	37,706,000	41,395,000	25,910,000	30,271,000
April	33,340,000	31,026,000	32,991,000	29,641,000	43,513,000	60,801,000	54,204,000
May	30,258,000	35,064,000	42,284,000	46,528,000	65,354,000	53,418,000	47,661,000
June	31,441,000	56,777,000	42,138,000	38,040,000	44,494,000	42,451,000	———
July	29,353,000	33,943,000	26,087,000	42,397,000	45,784,000	45,246,000	———
August	18,565,000	28,693,000	37,035,000	35,639,000	40,536,000	41,199,000	———
September	26,537,000	23,257,000	28,884,000	37,812,000	44,585,000	36,949,000	———
October	12,894,000	20,055,000	23,162,000	28,144,000	35,198,000	31,416,000	———
November	12,443,000	20,751,000	20,892,000	23,683,000	18,382,000	23,492,000	———
December	10,834,000	16,263,000	18,096,000	21,085,000	14,894,000	19,635,000	———
Total	$265,424,000	$315,856,000	$334,741,000	$381,097,000	$430,231,000	$423,341,000	———

Note.—About 100 per cent must be added to these totals to give the grand total of highway contracts in the United States.

Bridges are not included, and bridge contracts average 15 per cent as much in value as road and street contracts. A great deal of road and street work is done by directly hired labor and is not included above.

Asphalt Macadam in Northeastern States

Construction Details of Work in New York and New England Given in Paper Presented at Annual Meeting of New Hampshire Good Roads Association

By V. L. OSTRANDER
Of the Asphalt Association

One half of all bituminous macadam in the United States is found in New York and New England. The combined mileage of this type on all of the state systems of this country is approximately 9000 miles, while over 5500 miles are in this group of states, with over 4000 miles in New York state alone. The cities of the whole nation show some 33,000,000 yards of the type. New York and New England cities have over 16,000,000 yards of this total. These figures do not include waterbound macadams, with or without bituminous surface treatments, but include only the bituminous bound macadam built by the penetration method.

In New York state, of the 9800 milage of paved roads already built on their state system, a great frame work of over 4000 miles is asphalt macadam largely with its original surfacing, and with an average age of 10 years. This means some of these roads are 14 or 15 years old. This age would not be considered remarkable for pavements built under modern specifications but I recall that at the time these roads were built the usual base placed under them was only a 3-in. or 4-in. thickness of broken stone and motor trucks were non-existant. They were placed on new roadbeds which had never before been metalled. Their extent is so great as to cover all kinds of soil and drainage conditions.

Foundation Practice.—Present foundation practice in this section seems to be fairly uniform among the various states. As a rule, in entirely new construction, a foundation course of 8 to 10 in. depth of sledged stone or telford is placed by hand and filled with a good grade of gravel or broken stone. Every effort, is made to secure a smooth, true surface, with voids well filled. Sand or cinder blankets are growing in favor over soft subsoils to prevent the separation of the stones of this course through the working up of soft materials into the course. Where careful attention has been paid to occasional pockets of soft or spongy material, failures have been practically eliminated. Under especially unfavorable conditions the foundation depth is frequently increased to 12 in. and usually placed in two courses. Frequently the additional bearing power is secured through the use of a subfoundation of selected gravel in localities where suitable material is available.

Over this foundation the accepted present practice is to place a 2 or 2½ in. course of broken stone, to insure permanent filling of the voids in the foundation, to give a greater uniformity of surface to receive the penetration course, and to add strength to the section through the use of a small quanity of material most valuable for this purpose. The depth and sizes of stone for this course are varied to suit the particular conditions of the project, the intention being to use all the crushed product not required in the other course. Where the stone is not crushed locally, 2½ to 1½ size is generally used. The voids are filled with stone dust, clean sand or fine gravel. An excess of filler is not desirable and, in fact, better results obtain where the stone of this course is exposed for about ½ in. The filler should be dry when applied and should be put on in several light applications to insure a proper sifting down into the lower voids.

A thorough rolling of this course as well as the foundation course is essential. While there is some difference of opinion among experienced builders as to the advisability of full rolling on all kinds of stone in the penetration course, there is no doubt whatever as to the necessity for a most thorough consolidation of the lower courses. The possible breaking up of softer grades of stone has no harmful effect.

It is sometimes preferable to use a base of penetration macadam instead of the crushed stone base with stone filler. Such a treatment is most effective in resurfacing on old macadam or gravel road bed which has been consolidated to the utmost through years of travel. These beds may need strengthening or simply to have their crown reduced. In either case it is preferable to use the more substantial penetration course between the hard old base and the new surface course than to introduce a comparatively soft or loose course between the two.

The Penetration Course.—The penetration course as built in these states varies in sev-

eral ways. The best results seem to be obtained through the use of 2 or 2½ in. depth of finished course rather than with 3 in. or a greater depth. There seems to be less tendency toward displacement. Certainly it is possible better to fill the voids in the thinner course. The screen sizes vary from 2 to 2¾ in. maximum to 1 to 1½ in. minimum, the best results being obtained with the sizes 2¾ to 1¼ in. for hard stone, slightly larger for softer field or wall stone. The manipulation of this course varies in different sections and with different grades of stone. The result desired is a strong interlocking of the fragments. With a hard trap this can only be secured through considerable rolling before the first application of asphalt. But softer grades of stone will interlock under less rolling, while to continue to roll them at this stage will often crush the fragments to such an extent as to make proper penetration of the binder impossible. Regardless of the quality of the stone, a thorough rolling after completion of the pavement is always desirable. This back rolling should continue for several days during the warmest hours, and under traffic is practicable.

The thickness of the course spread loose should be the size of the largest screen opening. The stone should be spread to a tight line on pins not over 25 ft. apart. Roll enough to smooth out so the high spots may be seen. The high spots will usually be due to too many large stones while the low spots will result from an excess of small stone. Transfer some of the large stone to the low places and some of the smaller sizes to the places where the large sizes were taken out until the stone look uniform. Then roll again and take another look before pouring.

To get good results, the surface must present as nearly as possible a uniform amount of voids. The stone ought not to be rolled so tightly as to retain any surplus asphalt on the surface. After the first pouring cover quickly with clean pea stone and roll in order to stick the pea stone into the hot asphalt. Roll only lightly unless the road must be opened to traffic before the seal coat is applied. If so, use more pea stone and roll tight. Later sweep off surplus pea stone and apply seal coat, more pea stone and give a thorough rolling. Do not allow traffic ahead of the seal coat if it can possibly be avoided. And do not neglect thorough back rolling after all material have been applied.

A road built this way will have a toothy surface when the surplus pea stone have blown away and will retain this fine driving surface if pea stone and not too much bituminous material are used in maintaining it. Do not expect to get a good job unless the voids in the top are unforim before pouring. Don't expect to get a good job if there are large areas more than one stone thick. Stone must be clean and free from mud or dust. Stone for cover larger than ¾ in. are too large and too strong to go into the voids without wedging apart the stone already in place. Surplus sizes of stone should be used in foundations or on shoulders and all stone should be paid for by weight. In applying the asphalt 40 to 50 lb. pressure is about right and the temperature should be 330 degrees F. More trouble will be experienced with low temperature than with low pressure.

Massachusetts and Rhode Island Practice.—After the first application of asphalt, the Massachusetts practice is to use a smaller keystone than is specified in Rhode Island. This stone in Massachusetts is ¾ in. to ¼ in., and the same size is used as cover over the seal coat of asphalt. The Rhode Island practice is to use a keystone from a 1 in. to ⅜ in. size as filler for the penetration course, while for the final cover stone a ⅝ in. to ⅜ in size is used. In both states careful attention is paid to uniform distribution of this stone and the removal of any excess. This is essential if a riding surface that will stay smooth is to be secured. Uniformity is a prime requisite in this type as in most others. To secure uniform penetration from uniform pouring, it is necessary that the surface voids of the rolled course be uniform. This is not difficult of attainment if its absolute necessity is kept in mind.

In Massachusetts the first application of asphalt is 2 gal. per square yard for a 2½ in. course and 1¾ gal. for a 2 in. course, either being followed by a ½ gal. seal coat. Rhode Island pours 1¾ gal. first pour followed by ¾ to 1 gal. seal coat. The effect of these differences in sizes of keystone and rate of pour becomes evident after two or three year's service. The Massachuetts macadam is slower to fill to a smooth sheet-like surface. It remains toothy with the stone showing appreciably for several years longer period than is true in Rhode Island. These states are mentioned as theirs is the typical practice throughout New England, a practice which has secured most satisfactory results over a long period of years under traffic conditions that compare in severity with any that exist in a like area.

Practice in New York State.—In New York state, construction details have been different from the New England practice. Recently changes have been adopted to bring the work more nearly in line with the others, so that now the greatest difference lies in the hardness of the asphalt binder. New York, which for many years has used 120-150 penetration material, has recently changed to the 100-120 grade while the New England states specify 85-100 material. Also New York has built nearly all of her roads with a 3 in. top course, and with asphalt pours of 2 gal. or less for

both applications. While the New York roads are most of them high class roads their excellence has been secured at a higher maintenance cost than is necessary for the type. For instance, while Massachusetts seldom oils an asphalt macadam sooner than 7 or 8 years after construction, with an average of about 12 years before such a treatment, New York state averages such a treatment every third or fourth year.

Development of Foundations.—Foundations for asphalt penetration macadams not only play an important part in the success of the pavement but their development is of interest. Early foundations were light, in keeping with general construction of the time, usually 3 or 4 in. of course crushed rock, with the occasional strengthening of additional gravel. The use of gravel without a crushed rock cover was tried but generally found unsuccessful unless the gravel were of exceptional quality. With increasing weight of traffic, heavier foundations were seen to be necessary and an attempt was made to use a base of large stone, of say 8 in. greatest dimension, to give a greater depth of base but at a cost lower than possible with crushed product. The earlier examples were built without especial attention to the grade of filler for this course and with no intermediate course between it and the penetration surface course. The result was, that with soft filler frequently used, the top course stone would soon be pushed down into the larger voids of the foundation stone leaving an uneven surface. This roughness was two or three years making itself apparent so that a considerable mileage of road had been completed before the specification was improved. The requiring of screened gravel or crushed stone filler, together with an intermediate crushed stone course has corrected this difficulty. The depth of this large stone base course is now generally 8 in. minimum. There are locations where the available material is hard roundheads, many of a size ready for crushing but too large for base course where I believe a less depth, say 6 in. of crushed rock, would make a better foundation at less cost than the sledged stone with proper filler and leveling course.

Asphalt Macadam on Concrete Base.—There has been a limited yardage of asphalt macadam placed over Portland Cement concrete foundation in this section. Some of this was so designed originally, while in some cases the surfacing was placed so soon as it was realized that the concrete was unfit to serve longer as a surface. These foundations were usually 4, 5 or 6 in. in depth, 1:3:6 or 1:2½:5 mix, and sometimes of gravel aggregate. The results have been satisfactory. I recall two instances in central New York which have 4 in. gravel concrete bases, pitrun aggregate, about 1:2½:5 proportions, with 2½ in. asphalt macadam surfacings. These were laid in 1912 on the main streets of villages on through routes and are now in most excellent condition, with practically no repairs. Certainly, here the asphalt surfacing has extended the life of this concrete many times its natural life if left uncovered.

Chautauqua County, New York, is spending several million dollars on her county system of highways in addition to the state mileage in the county. Suitable local stone is not to be had. Their gravel is not sufficiently clean for hot mixed surface. However, her road building is in the hands of people of long experience in the construction and maintenance of high class pavements who realize "there are many ways of skinning a cat."' They use a 12 in. compacted depth of local gravel, placed in two courses for a foundation. Over this is placed a 4 in. compact depth of crushed blast furnace slag, this being the cheapest material of the sort to be had. This is followed by a 3 in. depth of penetration asphalt macadam of imported limestone. The whole cost of these 16 ft. wide roads, 19 in. deep, with a large portion of imported materials, and through terrain requiring about 7000 cu. yds. of grading per mile, averages between $20,000 and $25,000 per mile.

These same people have gone a long ways toward finding a suitable means of carpeting Portland cement concrete pavements that have begun to fail through disintegration or shattering. In Chautauqua County and the territory immediately adjacent, the state has more than 100 miles of Portland Cement concrete pavements now requiring resurfacing if they are to be salvaged as foundations. In an effort to hold them together until such time as funds are available for placing hot mixed tops, thin asphaltic surfacing have been placed. After much experimentation excellent results are being secured through the use of surface treatment of asphalt cut-back of about 35 per cent distillate and 100 penetration residue. Two applications of ¼ gal. each are given, each followed by rolling in of all the ¾ in. stone the cut back will carry. This treatment has been tried out over many miles of Portland cement concrete and is giving lasting results.

Stone for Wearing Course.—Throughout the greater part of New England it is considered essential that high quality, hard, tough stone only should be used in the wearing course of asphalt macadam. In many sections it is necessary to import such stone as the local stone does not qualify. While I would hesitate to criticise any leaning toward higher class construction, I feel that many times proper manipulation of the stone and selection of the binder will give first class results with stone of a softer nature. Such stone should not be rolled

more than enough to lock it together and smooth it out before the first application of asphalt. But it will withstand and it should have, a thorough back rolling after all the materials are in place. Also the sizes should be larger, and the manipulation should be such that the stone is not left exposed to wear and impact, but traffic should be carried on the asphalt and stone dust matrix. With this method, good results will usually be obtained automatically through the use of a soft stone if a reasonable quantity of asphalt is poured. Also a softer grade of asphalt will work better to pick up any broken fragments of rock. I have seen instances of such work in which there was used comparatively soft, thinly-laminated sandstone or loosely bound granites and that are affording excellent riding surfaces after ten years' service. Apparently they are good for many years yet. One such example is immediately adjacent to high grade crushed trap surfacing with identical traffic, soil and base conditions and presents just as excellent a surface and is, I believe, quite as satisfactory for the traffic imposed as the more expensive road of imported materials. I cite these opinions not with a desire to advocate lower standards of construction but once more to emphasize the adaptability of many kinds of local materials to some type of pavement with fair assurance of success. The savings that are possible frequently run into totals so large as positively to demand their acceptance.

In the Catskill and Adirondack mountain sections remote from railroad as well as in some of the southern sections of New York state, and in many sections of New Hampshire, Vermont and Maine, savings of more than $10,000 per mile may frequently be effected through the adaptation of the type to the materials at hand, and yet give a perfectly satisfactory pavement. For the asphalt macadam type usually the only material requiring importation is the asphalt and that only to the extent of about 120 tons per mile.

Construction Costs.—Construction costs vary with the locality, material, width, thickness, etc., as well as between original construction and resurfacing. In New York in 1925 the average cost per mile has been $32,000 for heavy construction work. In Massachuetts $45,000 per mile is given as the average, Rhode Island reports an average of $31,375 per mile for the past nine years' work, while Connecticut reports $23,200 for 1924. Recent maintenance costs are available only from Massachuetts which gives $.03¼ per sq. yd. and from Rhode Island which shows $.022 per sq. yd., or $232 per mile of 18 ft. road. The latest published figures from the large mileage in New York State are for the year 1922 and they show a maintenance cost of $445 per mile for asphalt macadam. For the reason we have already mentioned,—i. e., excessive oiling.—this figure is unnecessarily high. Also it must be remembered that these roads are old roads, averaging 10 years of service and were built before we realized what traffic was in store for them. There is no good reason why New York maintenance costs should be higher than Massachuetts or Rhode Island.

Two-Color Headlighting Proposed

A novel solution of the vexed problem of non-glaring headlamp illumination was described on June 2 at the summer meeting of the Society of Automotive Engineers by K. D. Chambers, scientific research engineer, in an address on complementary color headlighting.

Briefly, the proposed system consists in the use of oval headlamps each of which has two paraboloid reflectors, the upper one fitted with an orange colored glass and the lower one with blue glass, and of a color filter box just inside the windshield of the automobile in which are a sheet of plain transparent glass that filters out the orange rays and another that filters out the blue rays. These filters are connected electrically with the bulbs in the lamps so that when the orange filter is drawn down into the line of vision of the driver the blue light is turned off and the orange light turned on automatically, and when the blue filter is drawn down the orange light is shut off and the blue light turned on.

Each viewing filter is transparent to light of the same color and so the driver can see practically the same as if he were driving with white light and looking through an ordinary uncolored windshield with no approaching car causing glare.

When two cars equipped with this system approach each other, if one is using orange and the other blue lights, neither driver is blinded by the other's lights, but if both are using the same color, one driver will draw down the color screen to filter the other's light, simultaneously and automatically changing his own headlight to the opposite complementary color, and thereby protect the other driver as well as himself. When a car using the opposite color approaches, the viewing filter shuts out nearly all of the light rays from its lamps so that they appear as if dimmed almost to extinction.

If the system comes into general use, all will benefit. Then to simplify matters, a universal rule can be adopted that cars proceeding in a generally northerly direction and those going in a generally easterly direction shall show, say, orange light, while those moving in the opposite directions shall show blue light.

Capacity of Roadways

Studies for Varying Vehicular Speeds, Widths, Traffic Intervals, Etc., Given in Paper Presented April 22 at Fifth Annual Convention of Western Society of Engineers

By R. F. KELKER, Jr.

Of Kelker, DeLeuw & Co., Engineers, 111 West Washington St., Chicago

Roadway Capacity.—During the past few years there has been a great deal of discussion on the subject of highway capacity. The very considerable increase in traffic since the war has resulted in many instances of severe congestion and at the present time it requires but little observation to arrive at the conclusion that in many places our present highways lack the requisite capacity to conveniently and comfortably handle the traffic of today.

The survey made by the U. S. Bureau of Public Roads and the Cook County highway officials gives illuminating data as to volume of present traffic and contains, in addition, a carefully prepared estimate of the traffic conditions which may be expected in the near future.

Theoretical Maximum Capacity.—Having estimated the expected volume of traffic, the next step is to determine the width of roadway necessary to carry the traffic load. The convenient unit of highway capacity is the number of automobiles per hour per lane—the width of a lane is usually taken as a strip of roadway 10 ft. wide. The following formula is generally used:

$$\text{Number of Cars per Hour} = \frac{5280 \times \text{Speed in Miles Per Hour}}{\text{Distance in feet between Cars} + \text{average length of car.}}$$

The use of this formula necessitated the assumption of a divisor for various speeds; these assumptions were either the result of observations or based upon rates of deceleration developed by breaking tests. As a result, wide variations in the number of cars per hour have been given as the "maximum capacity" of a single lane. In some instances, the writer has seen calculations which were based on the distance between cars being the same as the distance required to bring a car to rest from various speeds; these distances being taken from publications of manufacturers for use of drivers in checking up on the performance of brakes. The error in this assumption lies in the fact that cars close up when coming to rest and the speed used, while running, is then reduced to nearly nothing. That the results thus obtained are in error is shown when they are compared with actual driving conditions and counts made on the highways. Calculations were later made based upon field

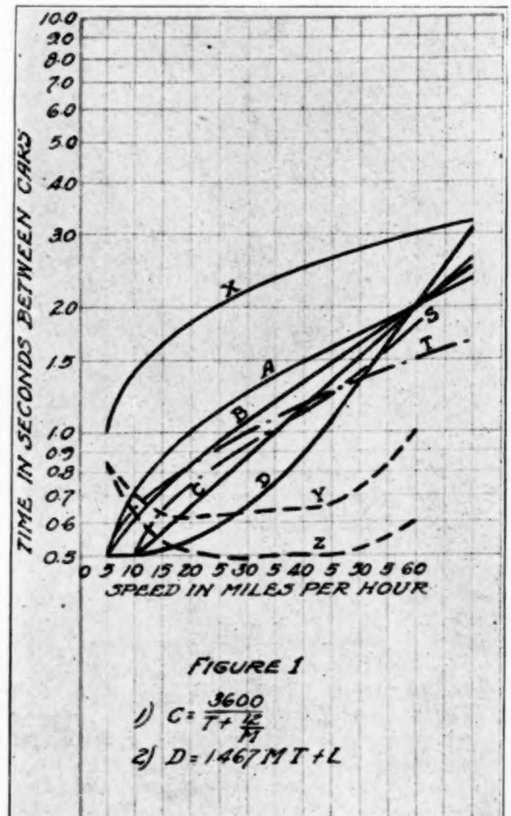
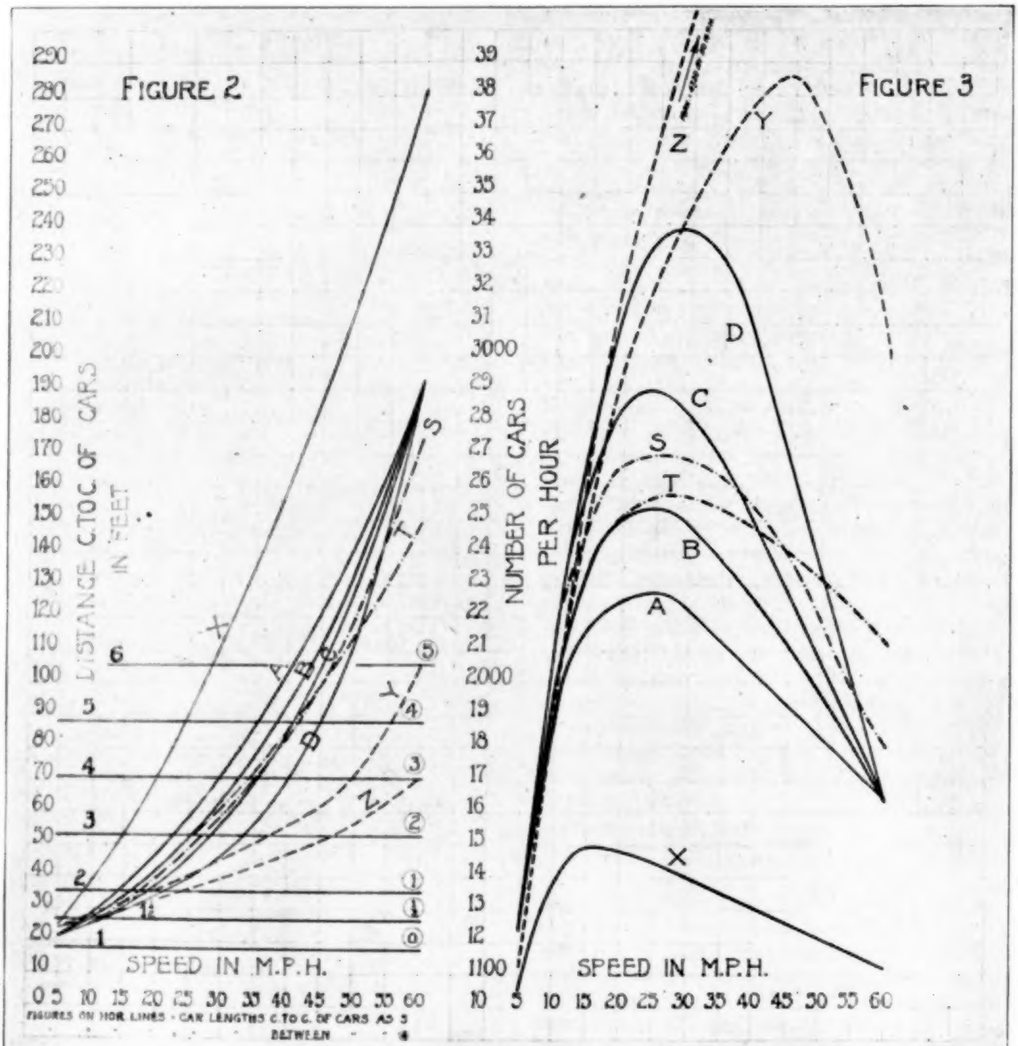


Fig. 1

observations of the actual spacing of cars at different speeds and in some cases moving picture cameras were used to obtain actual spacing. These data are interesting but cannot be used to determine "theoretical maximum capacity" for, as such data show nothing other

than the actual use of the roadway, the derivatives can only refer to use and cannot in any sense give a "theoretical maximum capacity." Such observations are said to have been made where it was thought the roadways were saturated. The writer has made many automobiles. However, if a "use" capacity is to be determined, the theoretical capacity must be multiplied by a constant less than unity which represents the combined expression of experience and field conditions, and the resulting product will be a working or practical



Figs. 2 and 3

personal observations in many cities from coast to coast and has never yet found a condition which could correctly be called true saturation.

Use Capacity.—The fact is simply this—to obtain a theoretical capacity it is obvious that theoretical conditions must be assumed based upon observations and habits of drivers of capacity suitable for making necessary estimates of the number of lanes required to permit the movement of a given number of cars in an hour.

On the two-lane highways during periods of heavy traffic, when the sightseer and real estate seller is absent, cars are driven along at a rate usually up to the speed limit. The

cars are spaced almost involuntarily by their respective drivers. When the opposing traffic is light, cross traffic lacking and good shoulders on the outside of the road, the spacing of cars approaches a minimum. The distance between cars selected by a safe but aggressive driver is based upon the road conditions, together with an estimate of the performance of the driver of the car ahead combined with his own ability to handle his car in its then condition, and added to these estimates is an instinctive measure of time required to sense a change in movement of the leading car and to change his driving speed accordingly. A combination of these elements is most conveniently expressed in seconds between cars and to this must be added for computations the seconds required for the car to move its length at the speed at which it is operated. Believing that a time element is more satisfactory than a distance element, the curves herewith presented were computed from the following simple formulas, using the symbols defined below:

Let C=Number of cars per hour per lane.
T=Time in seconds between cars.
D=Distance in feet between centers of cars.
S=Speed in feet per second.
M=Speed in miles per hour.
L=Length of longest passenger car in feet=17.6*

then $C = \dfrac{3600}{T + \dfrac{L}{S}}$

but $\dfrac{L}{S} = \dfrac{L}{\dfrac{88\text{ M}}{60}} = \dfrac{60\text{ L}}{88\text{ M}} = \dfrac{12}{\text{M}}$

$$C = \frac{3600}{T + \dfrac{12}{M}} \qquad (1)$$

as $T + \dfrac{12}{M}$ = Time in seconds between centers of cars

$$\text{then } D = \left(T + \frac{12}{M}\right)\frac{88\text{ M}}{60} = 1467\text{ MT} + 17.6 \qquad (2)$$

Using these formulas, assumptions were made, derivatives were computed and the Figs. 1, 2 and 3 were prepared to show in comparison nine different curves of three groups. Curves A, B, C and D (1st group) are variations of mean values; curves S and T (2nd group) are modifications of the first group and, of curves X, Y and Z (3rd group), curve X is a minimum limit and curve Z a maximum limit, with curve Y as a modification of curve Z.

Fig. 1 shows the assumptions used for spacing in seconds at varying speeds while Figs. 2 and 3 show the derivatives obtained by the use of the formulas (1) and (2) for the number of cars per lane per hour and for spacing of cars in feet, center to center, respectively.

Comparative Analysis of Assumptions.—As stated above, these assumptions are varied so that limits might be determined and many possibilities exhausted in order to reach, by comparative analysis, a logical conclusion. Aritho-log cross section paper was used and smooth curves drawn on the following bases:

Curve A. Two points were selected, 0.5 seconds at 5 mph and 2.0 seconds at 60 mph, and a curve drawn with a rapid rate of increase at lower speeds and a decreasing rate of increase for higher speeds.

Curve B. Same as curve A, but with a lower rate of increase, thus approaching a straight line.

Curve C. Two points were selected, 0.5 seconds at 10 mph, and, as in curve A, 2.0 seconds at 60 mph. These points were joined with a straight line.

Curve D. Same points as curve C, but with a low rate of increase at low speeds and rapidly increasing with high speeds.

Curve S. Two points selected, 0.5 seconds at 10 mph and 1.8 seconds at 60 mph. These points were connected with a reverse curve, rising rapidly at lower and at higher speeds, reversing with a lower rate of increase about 35 mph.

Curve T. Two points selected, 0.5 seconds at 5 mph and 1.5 seconds at 60 mph. This curve rapidly rises at low speeds, then with a decreasing rate, passes through the higher speeds on a straight line.

Curve X. Two points selected, as maximum limits, 1.0 second at 5 mph and 3.0 seconds at 60 mph. These points were joined with a curve similar to curve A.

Curve Z. This curve is based upon car lengths between cars. Three points were selected, ½ car length at 10 mph, 1 car length at 25 mph, and 3 car lengths at 60 mph, and a smooth curve passed through them. Distances in feet were read from the curve, converted into seconds between cars and the results were plotted on Fig. 1 for comparison.

Curve Y. This curve was constructed in the same manner as curve Z and has the same origin. Three other points were selected, 1 car length at 20 mph, 3 car lengths at 40 mph and 5 car lengths at 60 mph, connected by a smooth curve. The converted spacing in seconds was plotted on Fig. 1.

At the outset the values shown by curves X, Y and Z on Fig. 3 may be disregarded as they represent the probable approaches to the lower and upper limits of theoretical capacity. Curves A and B may also be dropped from the discussion as the assumptions as to change in rate of increases do not reflect field condi-

*This length is a maximum for passenger cars; if, however, a lesser length is substituted the spacing of cars will decrease and the capacities increase.

tions. Curve T can next be eliminated as the number of cars per hour at the highest speed seems excessive when considered in the light of current data available. The remaining curves, S, C and D, appear to be based upon sound assumptions and the probable theoretical maximum capacity will be within the limits indicated by them. The maximum point of output on curves S and C is about 25 miles per hour and about 30 miles per hour on Curve D. However, the decrease in output on either side of the maximum point taken at 20 and at 35 miles per hour is less than three per cent. for curves S and D and about seven per cent. for curve C. Consequently it may be said that for capacity curves the output is fairly constant for speeds between 20 and 35 miles per hour, with the probable but slightly higher maximum at about 25 to 30 miles per hour.

All of the curves, excepting curve X which is based upon faulty premises, show a great similarity in rates of increase up to and beyond 15 miles per hour and a decrease in rate of any substantial amount begins to show about 20 miles per hour, curve A excepted.

From these data the conclusion is reached that the theoretical maximum capacity of a single lane of roadway in cars per hour is not reached under 25 miles per hour and probably is actually attained at a higher rate of speed. Consequently calculations which show a theoretical maximum capacity at lower speeds are based upon observed use and not theoretical capacity.

Field Observations.—The foregoing discussion of capacity has been predicated only upon theories as to spacing of cars. For the purpose of comparing theory with practice extracts from field notes are given below. Instances of saturation in use of roadways have been eagerly sought and not found. It is possible to find apparent saturation for short periods of time but upon examination the conclusion must be reached that in reality these conditions represent blockades, due to the presence of a certain combination of controlling factors, and cannot properly be considered as examples of saturated use of roadways. Here in Chicago there are many places where the automobile traffic is very dense and all of these points where the use of roadways approaches a maximum, the greatest density of traffic per lane is found during the evening rush hour on the east (north-bound) side of the Michigan Ave. Bridge and on the same side of roadway of Lake Shore Drive, south of North Ave.

On the bridge the east half of the roadway measures 27 ft. in width, making a 3-lane roadway. The nearest traffic signal, affecting the north-bound traffic, is at Randolph St., about 1,500 ft. south. The signal cycle during the rush hour allows 64 per cent of the time for north-bound traffic. The total number of north-bound cars counted on the bridge in one hour was 3,619 or an average of 1,206 per lane, but the inner lane carried 1,552 cars during the same period or 43 per cent of the total traffic. Had not cross traffic at Randolph St. been given 36 per cent of the time and had the traffic flowed continuously, the output of the inner lane would have been 2,410 cars and that of the entire north-bound roadway 5,620 cars. This observation also showed that the actual use of the three-lane roadway was but 77.7 per cent of the number of cars which would have passed the checking station had the output of the center and outer lanes been the same as that of the inner lane.

Observations of traffic made on the east half of the roadway of Lake Shore Drive at Schiller St., where there is no cross traffic, and where there is only an occasional delay due to left-hand turns from the inner lane, show an output for one hour of 1,949, or an average of 975 cars per lane, but the inner lane carried 1,096 cars or 56.4 per cent of the total traffic. During the maximum 5-minute period 108 cars passed the checking station on the inner lane at an average speed of 24.9 miles per hour. Traffic movements were somewhat affected by the signals at Oak St., ½ mile south, and the portion of the signal cycle given to north-bound traffic at that point is about 70 per cent of the total. Had all the time been given to north-bound traffic and had the flow of cars been continuous, the above figures would have been increased to 2,784 cars for the two north-bound lanes, 1,393 for the average lane, 1,566 for the inner lane for the hour period, and 1,852 for the same lane based on the rate for the maximum 5-minute period.

Taking the maximum 5-minute period which showed 108 cars (a rate of 1,296 cars per hour) moving at an average speed of 24.9 miles per hour, the average space between centers of cars was 101.4 feet. Assuming 100 per cent of the time devoted to north-bound traffic, and a sufficient number of cars to maintain the rated output, the average spacing would be decreased to 71 ft., center to center of cars. To any one familiar with rush hour traffic conditions on Lake Shore Drive an average spacing of slightly over 100 ft. must appear to be entirely out of line with actual driving conditions. Cars move in groups, aside from signal interference, consequently the spacing between groups must be discarded and that between individual cars in the groups used. Within groups the spacing was 45 ft. or less, so any curves of theoretical capacity such as X, A and B, with a spacing at 25 miles per

hour of 91, 58 and 52 ft. respectively, are not representative.

These observations at an average speed of 24.9 miles per hour may be summarized as follows:

	Spacing C. to C. of cars	No. of Cars per hour	Efficiency or use factor
Observed average	101.4	1,296	0.390
Observed average — signal cycle eliminated	71.0	1,852	0.553
Observed average — cars in groups	45.0	2,430	0.732
Observed minimum spacing of cars	33.0	3,320	1.000

As these results are from observations on a heavy traveled roadway and for the 5-minute period of maximum traffic, it must be obvious that there were not nearly enough cars being operated to approach anything like maximum capacity or saturation.

Width of Roadways.—The second factor which must be considered is the value of additional lanes. Neglecting parking lanes the capacity values of roadways of various widths may be stated as follows:

Lanes in each Direction	Total Lanes	Efficiency in per cent
1	2	100 assumed
2	4	89 actual
3	6	78 "
4	8	65 estimated
5	10	52 "

It appears that when cars driven in broad roadways are not held to certain lanes, there is needless weaving in and out of the various lanes and hence uniformity of movement is reduced and efficiency is lowered. These figures representing efficiency may be put on an equivalent basis for the purpose of comparing approximate costs and traffic values of roadways, with two parking lanes of 7 ft. each added to the lanes used my moving traffic.

Width of Roadway Ft.	Relative Traffic Values
34	200
54	356
74	448

From these values it may be computed that the construction of two roadways, one 34 ft. and one 54 ft. in width, will cost 19 per cent more than one 74 ft. roadway, but the traffic values of the two roadways is 24 per cent greater. Similarly, two streets with 54 ft. roadways can be built at an increase in cost of 46 per cent over the cost of a 74 ft. roadway but these two roadways will have a 57 per cent greater traffic value. In each of these cases parking space at curbs will be increased 100 per cent over the spaec of a 74 ft. roadway. (Costs are assumed to vary directly with widths.) These computations show that two reasonably wide streets are more effective than one very wide street and further two streets are a material aid in avoiding the concentration of traffic movements and the consequent congestion. When these relations are considered for roadways of a greater width than 74 ft. the spread between values and capacity is further increased. The increased hazard for pedestrians as well as the delays to traffic they cause in crossing them is a further argument against very wide roadways. Only under special conditions can the construction of wide roadways be justified.

Effect of Signals.—The use of stop and go signals of one description or another has become widespread. In many cases they are placed in such a manner as to retard traffic movements unnecessarily. When two streets intersect, without traffic control, and the traffic on each is heavy, tangles and blockades are bound to occur and all traffic is delayed. When these delays, either in areas or at a single intersection, are recurrent throughout a substantial period of time so that traffic movement is retarded during one-third or one-half of the period, then the installation of signals will aid in securing uniformity in movements. It must not be forgotten that the signals will. of necessity, prevent the use of each of the intersecting streets for an average of 50 per cent of the time. Therefore, only when delays are of consequence and recurrent in character and at least equal to the reduction in capacity due to signal operation can signals be installed without reducing capacity. A group of signals where warranted, with master control that will permit individual adjustments for each intersection, will prove of greater aid in moving traffic than the hit or miss installation of signals at single intersections. Many of the signals used have the yellow cautionary color in addition to the red and green colors, to allow time for pedestrians to cross the roadway. Consequently the capacity of a roadway or lane is reduced to the ratio of the green or "go" light to the signal cycle and this ratio is usually 50 per cent. If, however, the cross traffic pedestrian movements are light, the ratio is usually increased.

Conclusions

A. For Theoretical Maximum Capacity:

1. The output of an unobstructed single lane is upwards of 3,300 cars per hour.
2. The speed of cars for this output is upwards of 25 miles per hour.
3. The variation in output between 20 and 35 miles per hour is inconsequential.

B. For Practical or Use Capacity:

1. The output per lane per hour where, at points of heavy cross traffic a good system of control is installed, is upwards of 1,500 cars.

2. As interruptions of flow only reduce the amount of time available for moving traffic, the factors relating to speed remain unchanged.

3. Approximate factors to estimate the use of a single lane in output per hour are upwards of the following figures:

	Factors	Cars
Controlled highways	0.45	1,500
City street—automobile traffic predominating	0.24	800
City street—a single lane parallel to street car track	0.18	600

C. Capacity of Multiple Lane Roadways:

1. The inner lane carries the greatest volume of traffic.

2. As the number of lanes increases the average output per lane decreases.

3. Comparison of cost (based on width) and of capacity indicate that roadways having eight or more lanes are not economical when their construction is determined solely by estimated traffic values.

4. Six lane roadways, particularly when combined with a system of four lane roadways, appear to be the most economical from a point of view of cost and capacity.

D. Speed of Cars:

1. There is no apparent foundation for the theory that the spacing of cars varies with the square of the speed.

2. To obtain the greatest output per lane, drivers of cars should be required to move at the authorized speed limit. This fact once recognized will enable motorists to get the most efficient use of highways. Slower moving cars obstruct traffic, diminish output and increase the desire for passing with its consequent hazards.

3. Mixed traffic prevents movement of cars at a uniform speed. This is a factor which lowers average speed and decreases output.

E. Signs and Signals:

1. Signs other than those of an informatory nature, should not be installed unless traffic conditions actually warrant their use and the police are prepared to enforce the regulations shown on them.

2. Aside from consideration of safety, traffic signals at isolated intersections should be provided only where disorderly movements and recurrent delays have reduced the output by an amount greater than the reduction that would be imposed by traffic control.

3. If traffic control is provided by the installation of traffic signals at contiguous intersections in an area, they should be operated progressively by a master control in order to avoid loss of street capacity.

Road and Street Widening Projects

The movement to widen roads and streets, especially in and around the larger cities, is gaining impetus in every section of the country. Roads and streets designed for the traffic of even five years ago are in many instances wholly inadequate. Streets and roads planned and paved while motor vehicle traffic was speculative are today choked by a volume of traffic which oftentimes moves at a pace slower than that of the days when all vehicles were drawn by horses.

A few of the most recent widening projects are listed as follows in the June Concrete Highway Magazine:

PENNSYLVANIA

The citizens of Pittsburgh on May 18 approved bond issues totaling $7,997,000 for widening and improving streets.

Philadephia has approved a bond issue of $54,750,000 for improvements, including streets and subways.

OREGON

On May 21, a bond issue of $1,500,000 was passed in Portland to be used for widening bridge approach streets. On the same day Multnomah County approved $2,500,000 bonds to be used for widening main arterial highways.

NEW JERSEY

Camden is widening a number of streets, the most notable project being the approach to the new Delaware River Bridge.

NEW YORK

Nassau County and Long Island are securing wider rights of way up to 160 feet along main roads.

The widening of Montauk Highway (all concrete), is planned for 36 miles to accommodate three lanes of traffic.

Jericho Turnpike—Ten miles of 40-foot concrete will be laid during 1926.

Conduit Boulevard and Southern State Parkway pavement will be constructed of concrete 40 feet wide.

The Trend of Motor Vehicle Legislation

The Present Tendency Outlined in Address Presented April 30 at Annual Meeting of National Highway Traffic Association

By RUSSELL HUFFMAN
Secretary Motor Vehicle Conference Committee

It must be kept in mind that the laws affecting motor vehicles are scarcely 25 years old. Twenty-five years ago such laws were in force in only a few states, and they were extremely few in number. The greater proportion of motor vehicle legislation has been enacted during the past 15 years. Because it was a subject with which the lawmakers were unfamiliar, and because there have been so many different legislative bodies enacting these laws, it is quite natural that there should be a great lack of uniformity, and, in some instances, unfair regulation. When the above facts are carefully considered we are forced to come to the conclusion that, after all, things are not in as chaotic a condition as they might have been. The tendency at the present time is toward a much greater uniformity and this tendency promises to rapidly materialize during the next five years. This movement is now making rapid strides, even though the results are not readily observable in some phases of motor vehicle regulation.

Legislative and Regulatory Authority Over Motor Vehicles.—There are three jurisdictions here in the United States which have authority to regulate the use and operation of the motor vehicle through legislation. These jurisdictions are the Federal Government, the 48 state governments and the municipal governments, which number several thousand. Because of this peculiar situation it can be easily understood why motor vehicle regulations have been so lacking in uniformity and so particularly diversified in their application. As yet, the Federal Government has enacted no laws regulating motor vehicles, although Congress is at the present moment seriously considering the passage of a bill designed to regulate bus and truck lines operating in interstate commerce. The several thousand municipalities have, however, through their authority to pass ordinances, enacted a great many regulations, particularly those applying to traffic rules, which have become no small part of the total mass of rules and regulations affecting the motorist. However, the most important motor vehicle legislation has been enacted by the state legislatures, and it is to this type of legislation that I expect to devote a greater part of this discussion, in my attempt to give a brief review of the situation.

Increase in the Volume of State Legislation.—In the past five years there has been a marked increase in the number of bills introduced in the state legislatures designed to regulate or to apply to the motor vehicle. In 1921, with 42 state legislatures meeting, the total number of bills introduced approximated 2,000; in 1923, when the same number of legislatures were in session, this number was 2200; in 1924, with only nine states meeting in regular session, this total was 600 bills. However, in 1925, with 42 state legislatures again meeting the number had increased to approximately 2500. During the present year of 1926, which is known as a "light year," because only nine states have held regular sessions, the total number of bills introduced approximates 750. If the 1926 average is maintained in 1927 there will be at least 3600 bills introduced and considered by state legislatures which relate to the motor vehicle.

A relatively large proportion of these bills have been enacted into laws. In 1921 this amount was about 400; in 1923, 450; in 1924, about 150. In 1925, this number increased, due to the fact that most of the states were in session, to 563. The 1926 records are not complete, but the indications are that there will be approximately 150 new motor vehicle laws added to the state statutes.

Trend of More Important Phases of Motor Vehicle Legislation.—The field of motor vehicle legislation is so broad that it would be impossible to give you anything more than a brief review of what has taken place during the past few years with reference to the more important subjects. Briefly, this tendency has been as follows:

Registration and license fees have gradually increased, particularly with reference to trucks and buses. There has been a marked tendency to increase the gasoline taxes.

With reference to size, the tendency has been to gradually decrease the allowable width of buses and trucks. Likewise, there has been a growing tendency to reduce the gross weight limitation permitted buses and trucks.

The tendency, with reference to speed regulations, has been to permit a much higher rate, and this has been particularly true during the past two years.

Motor vehicles operating for hire, commonly

called common carrier vehicles, have been more and more regulated by the state governments, and this tendency has developed quite rapidly during the past few years.

State lawmakers are rapidly seeing the need of requiring all drivers of motor vehicles to be examined and licensed before being permitted to drive, and this has resulted in the enactment of driver's license and examination laws in many of the states.

Certificate of title laws, designed to prevent the sale of, and aid in the recovery of, stolen motor vehicles are becoming more and more common.

There has been much agitation during the past few years for compulsory automobile liability insurance, or, some method of fixing the owner's responsibility for accidents caused by his motor vehicle. This agitation, however, has not resulted, as yet, in the enactment of much legislation on this subject.

Equipment of motor vehicles, such as lights and brakes, more especially headlights, has been receiving a great deal of attention at the hands of the legislators. Headlight regulation is still in a very unsatisfactory condition.

There is a decided advancement toward uniform traffic laws and rules of the road, and while, apparently, still in a chaotic condition, they are gradually being unified through the process of educational work carried on by the motorists and their organizations.

In the matter of enforcement, the tendency has been toward the application of much stricter penalties and more rigid enforcement of the laws, especially those directed toward the careless and intoxicated drivers.

Discussing these more important phases of motor vehicles legislation in greater detail, we find that some interesting facts are developed.

Registration and License Fees.—The first state registration fee law was enacted in 1901. By 1915 every state in the union had levied such fees. Naturally, the tendency has been toward an increase in these fees, especially with reference to commercial cars, although during the past two years this tendency has greatly diminished because of the rapid adoption of a new form of tax, namely, the gasoline tax. There is a great diversity among the states in the methods of assessing motor vehicle registration fees. In fact, there are about twelve different bases now being employed in determining passenger car fees and nineteen in determining commercial car fees. Some states charge a flat rate fee; some base the fee on horsepower; some on weight; some on capacity; some on value and some on a combination of the above factors. It probably will be a long while before all the states have adopted a uniform method of assessing their registration fees. During the past two years only three states have materially changed their method in this respect. The most marked increase in registration fees affects buses and trucks. Figures compiled by the Bureau of Public Roads in 1923 showed that in 29 states the fee paid for the average truck was more than twice as great as the average fee paid per passenger car. No doubt this average has increased since that time.

This increase in registration and license fees can be shown by making a comparison of the increase in the number of motor vehicles with the increase in the total amount of fees paid. In 1915, there were 2,445,666 vehicles registered in all the states, paying total fees amounting to $18,245,711. In 1925, there were 19,954,347 vehicles registered and the total of the fees paid was $260,619,621. This shows that in the ten year period the number of motor vehicles increased approximately 8⅛ times while the registration fees increased approximately 14⅓ times. This increase is also very definitely shown by comparing the average fees per car in 1915 with those in 1925. In 1915, the average was approximately $7.45 per car, while in 1925 it was approximately $13.05 per car or almost 100 per cent increase.

Gasoline Tax.—One of the most outstanding developments in motor vehicle legislation during the past few years has been the popularity and spread of the gasoline tax. This form of tax has been seized upon by the state legislators as the easiest method of assessing taxes on the users of the highway. The chief argument used in favor of the gasoline tax is that it is the best method yet devised, which enables the state to charge the motorist for the amount of use he gets out of the highway, since the amount of the tax will depend upon the number of miles he has traveled. The first state to enact a gasoline tax was Oregon in 1919, and so rapidly has this spread that at the present time 44 out of the 48 states have such laws. Recent figures issued by the Bureau of Public Roads show that the average gasoline tax in the whole United States is 2.26 ct. per gallon, and that the average consumption per car is 430 gal. per year. The total amount of gasoline taxes collected in the United States during 1925 was $146,000,000. One need not be a prophet to predict that the motor vehicle users will, within the next five years, be paying annually $250,000,000 in gasoline taxes.

The adoption of the gasoline taxes has not been followed by a decrease in the registration fees, as might be expected. The tendency has been to make them an additional tax rather than a substitute. In only three states has the adoption of the gasoline tax resulted in a decrease in the registration fees.

Disposition of Motor Vehicle Tax Funds.—One of the most noticeable features in con-

nection with registration fees and gasoline taxes has to do with the disposition of the funds collected from these sources. In former years, a considerable portion of the total amount collected was used for purposes other than highway development. The tendency now is to use these funds purely for highway purposes. In 1921, the sum of approximately \$18,000,000 out of a total of \$133,000,000 collected from registration fees and gasoline taxes was diverted from highway purposes. In 1925, out of a total of \$260,000,000 collected from registration fees, all but about \$3,300,000 went to highway purposes. Of the \$146,000,000 collected from gasoline taxes in 1925 about \$11,000,000 was used for other than highway uses. Adding this to the \$3,300,000 which represents the amount of the registration and license fees not used for highway purposes, you have the sum of approximately \$14,000,000 out of the total motor vehicle revenues from these sources, namely \$406,000,000, which was not used for highways. This is less than 4 per cent and indicates how well the motoring public is watching the expenditure of funds collected from them. No other form of special tax revenue, in my opinion, has been so closely kept to its purpose. Within the next few years, no doubt, changes will be made in the state laws so that every cent collected will be used for highway development.

Highway Development. — Highway development, while not a part of motor vehicle regulation, is so closely associated with the general subject that no review would be complete without briefly indicating the rapid progress being made in the construction of our highway facilities. Figures compiled by the Bureau of Public Roads show that in 1904 the total highway mileage in this country was 2,151,379 miles. The total number of miles in that which could be classified as "surfaced highways" was 153,530, representing 7.14 per cent of the total mileage of all highways. In 1925, the total amount of highway mileage had increased to 3,002,116 miles and the amount of "surfaced mileage" to 495,000 miles. Sixteen and one-half per cent of the total mileage may now be classified as surfaced highways. There can be no doubt that this percentage will rapidly increase when we take into consideration the fact that we have been spending, approximately a billion dollars annually for highways during the past few years.

Size, Weight and Speed.—At the present time three-fourths of the states have enacted laws regulating the width and height of motor vehicles. These regulations, of course, only affect buses and trucks. In 1921, only one-half of the states had such regulations. The greatest width permitted in any state at the present time is 108 inches, and the narrowest width is 84 inches. The majority of the states have fixed the width limit at 96 inches and the height at 12 ft. 6 in. It must be noted, however, that the tendency is toward the reduction in the permissible width.

All the states but three have enacted regulations fixing the weight of vehicles operating over the highways. In 1921, 40 states had such requirements. These requirements, generally, not only fix the gross weight and capacity weight permitted on four wheels, but also the axle and per inch width of tire weight. The gross weight limitation ranges from 30,000 lb. to 18,000 lb., the average being about 24,000 lb. Practically every state has a provision in its law which permits state and local highway officials to decrease this weight allowance when the weather conditions have softened the roads so that it would be inadvisable to permit heavy vehicles to operate.

One of the noticeable movements during the past two years with reference to weight limitations is the tendency on the part of the highway officials to base the weight allowance upon the charatcer of the highway over which the vehicle is to operate. This is known as the classification of highways. Under this method all highways are divided into four classes—terminal highways, highways connecting industrial centers, intermediate highways and local highways. Under this plan the heavy loads are confined to those highways constructed to carry such weight. While no state has yet enacted such a law several of the state highway officials are using this plan to fix the weight permitted over certain of the state highways. There is no doubt but that this plan has great merit, and it may go a long way toward solving the difficulties as regards highway weight regulations which exist now in a great many of the states.

During the past five years there has been a very noticeable tendency toward increases in the legal speed permitted in the states, both within cities and outside cities. In 1901 when the state of New York passed its first speed laws, the limits were fixed at 8 miles per hour in built up sections and 15 per hour in open country. No state at the present time has such low restrictions. The average now is at least 30 miles per hour in open country, and some states have fixed it as high as 45 miles per hour. In 1925, the legislatures of ten states changed their speed laws, and in each case this change represented an increase in the allowable maximum speed. This tendency is due largely to the fact that it has been found necessary to speed up traffic in order to relieve the highways of congestion. This method has been found exceptionally successful in large cities where certain streets have been set aside for fast traffic and in certain states where some of the main highways have been

loaded with an exceptional heavy amount of traffic.

It is interesting to note at this time that one of the very recent developments with reference to speed regulations is the tendency toward a minimum speed limit rather than a maximum limit. There is considerable agitation at the present time for minimum speed laws among some of the state highway officials, and at least one state has enacted a law which prohibits the operation of a motor vehicle on the highways which cannot maintain a certain minimum speed.

Common Carrier Regulations.—The regulation of motor vehicles can be classified into two divisions—namely (a) the regulation of the physical operation of the vehicle, and (b) the regulation of the business of operating motor vehicles for hire. This latter class has to do with what is commonly known as common carrier regulations which has been placed largely under the jurisdiction of the state public utilities bodies. The regulations of the physical operation of motor vehicles is largely in the hands of the commissioner of motor vehicles or similar administrative officer.

During the past few years there has been a decided tendency toward state regulation of the business of operating motor vehicles for hire. In 1914, Pennsylvania passed the first law of this kind. At the present time 37 states have enacted laws regulating buses to a greater or lesser degree, and 30 states have laws regulating trucks. In the case of truck regulation, while 30 states have enacted such laws, not all of them attempt to regulate the complete operation of the business, especially as it concerns rates and tariffs. In 1925, eight states enacted new laws of this character. There is no doubt but that the year 1927 will see several more laws of this kind placed upon the statute books.

During the past two years there has been a growing desire on the part of the state public utilities bodies to increase their jurisdiction not only over the business of operating, but also, over the physical operation of the vehicle. This is evidenced by the fact that at least one state public utilities body has issued, in the form of regulations, a complete set of specifications regarding the size and length of body, the equipments and lights to which all buses must conform before they will be permitted to operate. Recently, the States of Massachusetts and Connecticut have issued regulations which include requirements relating to the kind of lights and other equipment of buses which have heretofore been left to the Motor Vehicle Department.

Driver's License and Examination Laws.—In the interest of safety many of the states, eighteen in all, have enacted laws, which requires that every operator of a motor vehicle shall be licensed before being permitted to drive his vehicle over the highways. Thirty-six states require all chauffeurs to take out licenses. In many of these states an examination is required before the license is issued. The purpose of the examination is to determine the physical and mental qualifications of the driver with reference to his ability to handle a vehicle and his ability to understand the highway traffic rules. These laws have been quite generally accepted, not only by the automobile industry, but also by the whole motoring public, as one of the most important factors in the interest of safety. This was clearly brought out by the deliberations of two meetings of the National Conference on Street and Highway Safety, known as the Hoover Conferences, and at both these Conferences driver's license and examination laws were recommended as one of the most important means of bringing about a reduction of highway accidents. There is no doubt but that the next few years will find the enactment of such laws in practically all of the states.

Certificate of Title.—Certificate of Title Laws have been enacted in about twenty of the states. The purpose of these laws is to prevent the disposal of stolen vehicles, and to aid in the recovery of such vehicles. In a state where such a law is in force the purchaser of a second hand car is protected because he knows that the seller of the car must give him a Certificate of Title proving his ownership, and that such ownership is recorded with the State Motor Vehicle Department. It is pretty generally agreed by the whole automobile public that such laws, when adopted in all of the states, will make it practically impossible for thieves to carry on any traffic in stolen vehicles. As an indication of how rapidly these laws are being adopted, it should be noted that eight states enacted them in 1925. Many more states will, no doubt, accept this plan during the meeting of their legislatures in 1927.

Compulsory Automobile Liability Insurance.—One of the newest forms of legislation to come before the motoring public is compulsory automobile liability insurance. Many people believe that every owner of a motor vehicle should be required to carry liability insurance in order that his responsibility to pay damages be established in case he is involved in an accident. The first bill of this character was introduced about six years ago and so rapidly has its popularity spread that in 1925 no less than 26 state legislatures were considering such measures. Out of this summer only one state has enacted such a law, namely Massachusetts. The Massachusetts law will not go into effect until January, 1927, so it can be correctly said that compulsory insurance is not in operation in any state in the United States

at the present time. Time does not permit to enter into a discussion of the pros and cons of this insurance, but it should be remembered that there are few facts or data in existence in the United States at the present time which bear out the contentions of the proponents that it is a beneficial plan or that it will operate successfully. It would be very advisable for the motoring public to withhold their affirmation of this kind of insurance until actual facts are at hand to prove its success. It should be noted that practically all insurance companies are opposed to this plan and national automobile organizations, such as the American Automobile Associations, National Automobile Chamber of Commerce and National Automobile Dealers Association have emphatically opposed the enactment of such legislation.

Motor Vehicle Equipment.—The most important phase of automobile equipment, so far as legislative regulation is concerned, is that which relates to lights. At the present time there is a great difference of opinion among lighting experts as to how this question should be settled. Because it is a highly technical problem and because the average law maker is unfamiliar with such problems, we have on the statute books a great many confusing laws on the question of headlights. There is a decided lack of uniformity among the states as to these requirements, and, in some cases, a great deal of trouble has been caused motorists traveling from one state into another. This problem has been solved to a great extent in the Eastern Atlantic section of the United States through the uniform rules and regulations adopted by the Eastern Conference of Motor Vehicle Administrators, an organization which consists of the administrative officers of eleven of the eastern states, extending from Maine to Virginia. The problem of motor vehicle headlights is now being studied by the technical and engineering organizations connected with the automobile industry, and no doubt a satisfactory answer will be found within the next few years.

Probably the next important phase of motor vehicle equipment, so far as regulation is concerned, relates to brakes. All but two states have laws touching on the subject of brakes, but in most of these laws no mention is made of any technical requirements. Most of the laws merely state that the brakes must be "adequate and sufficient." For the past two years, however, there has been a tendency on the part of some of the state administrative officers to require that the brakes be capable of certain performances before being permitted to operate on the highways. In order that a fair test be made, a section committee of the American Engineering Standards Committee is now at work on a safety code for brakes, in which certain definite requirements are set up for braking performances based upon the speed of the vehicle and the condition of the highway surface. The experience data upon which this code is based was compiled by the Bureau of Standards from actual tests made on several hundred cars. If this code is adopted, the state administrative officers will have something to guide them in their examination and investigation of brakes which will be based on fair standards of performance.

There has been little change during the past several years in the state laws relating to other equipment, such as mufflers, mirrors, signaling devices, etc. Practically every state requires that all motor vehicles have such equipment, but few attempts have been made to specify the design. This has been left largely to the manufacturers.

Traffic Regulations. — The most noticeable lack of uniformity, which directly affects the motorist himself, has to do with traffic regulations or the so-called "rules of the road." Every one knows that there is a great confusion in the state laws regarding such regulation. Even within the individual states, there is a great lack of uniformity, since many municipalities have authority to regulate traffic within their limits.

As a result, motorists going from one state to another are continually confused because they do not know what traffic regulations are in force. This situation has become so acute that a campaign of publicity has been going on during the past few years in the attempt to bring about some change. So important was this problem that the two National Conferences on Street and Highway Safety held in 1924 and in 1926 give a great deal of consideration to possible remedies and, as a result, the 1926 Conference recommended a uniform motor vehicle code which contained a complete set of traffic regulations. If this uniform vehicle code is adopted by all of the states this troublesome problem will soon be settled.

Enforcement and Penalties.—The past few years has seen a decided tendency on the part of the law makers to inflict heavier and more stringent penalties upon motorists who have failed to heed the laws. There has also been a decided movement toward a stricter enforcement of these laws. One of the most noticeable steps in this direction is the establishment of state traffic police forces in a number of the states. Furthermore, this problem has been handled in the municipalities through the establishment of special departments of police known as traffic departments, and the use of a large number of policemen in each of the larger cities for traffic duty alone. The courts, too, have become very active in the enforcement of the laws, and penalties are being inflicted much more readily than ever before.

Many states have recently placed very heavy penalties upon the careless and intoxicated driver. The need for this can readily be seen when an examination has been made of the number of accidents caused by these two classes of drivers.

Organization.—The attitude of the motorist has rapidly changed in recent years until at the present time the great majority of motor vehicle users have come to realize that they are, more or less, responsible for the type and character of regulatory legislation. The first motor vehicle laws were drafted by legislators who had little knowledge of the needs of the motorist or the conditions regarding motor vehicle operation. The past few years has seen a decided change in this respect. Motorists now realize that it is their duty to educate the law makers to the needs of sound motor vehicle regulation. As a result of this, the more recent laws are much more reasonable and much more capable of enforcement.

The present time finds the industry and the motoring public very well organized. The manufacturers have a strong national organization; the dealers are organized in practically every state and also are represented by a national organization; the owners of motor vehicles, now number practically twenty millions of people, not only have their local automobile clubs and state organizations, but also are under the guidance and leadership of a strong national organization, namely the American Automobile Association. Just recently the bus operators of the country have been organized into a national group which is affiliated with this association. At the present time truck owners comprise the only class of motor vehicle operators which is not well organized, and it is hoped that the next few months will see them united into an effective national group. It can be safely said that the motoring public and the industry is entering into the year 1927, when forty-seven State Legislatures convene, well prepared to guide and direct the character of motor vehicle legislation.

Expansion Joints in Concrete Pavements

The contractor may save himself from subsequent trouble by careful attention to the placing of expansion joint material. Inspectors pay particular attention to the trueness of surface at joints and any irregularities will be quickly detected.

A few simple essentials that should be kept in mind when placing expansion joints are outlined as follows in the Concrete Highway Magazine:

The slabs separated by an expansion joint of any kind must be actually separated and no joint connected by concrete flowing around the edge, or over the top of the expansion joint material. To facilitate the finishing operations, the expansion joint is sometimes depressed slightly below the surface but afterwards opened up and the edges tooled, leaving a clean, free joint.

Finishing Expansion Joint with Long-Handled Split Float

It is of utmost importance to have the joint truly vertical. Several types of removable bulkheads have been devised to hold the joint material in position, and when properly and carefully staked in place, are all advantageous in securing a good joint.

Where the expansion joint material projects above the surface during construction, both sides of the joint should be finished simultaneously, preferably 3 feet on either side. For this purpose a long-handled split float is an excellent piece of equipment.

A joint finished in this manner will have no "high spots" to rub down with carborundum brick, a tedious and expensive process.

City Planning and Traffic Congestion

A Plan for Eliminating Congestion of Traffic Described at Joint Meeting of American City Planning Institute and City Planning Division, American Society of Civil Engineers

By NOULAN CAUCHON
President, Town Planning Institute of Canada

Congestion comes of ill proportioned functions and inadequate services, nearly all variables from lack of definite purpose. Congestion comes of the lack of functional, organic town planning, defined as "the scientific and orderly disposition of land and buildings in use and development, with a view to obviating congestion and securing economic and social efficiency, health and well-being in urban and rural communities.", Congestion comes of inadequacy of living conditions, due to shape and disposition of blocks, to over density of population; of the scheme of streets and arteries being ill proportioned in width, length, direction and capacity.

Congestion comes of lack of comprehensive zoning for "use and development," for meeting occupational requirements of spacing, height and bulk of buildings. Congestion comes of lack of zoning the density of population. An organic plan of streets and arteries should be calculated in dimensions and correlated to the fluid ebb and flow of population and traffic within the population-shed.

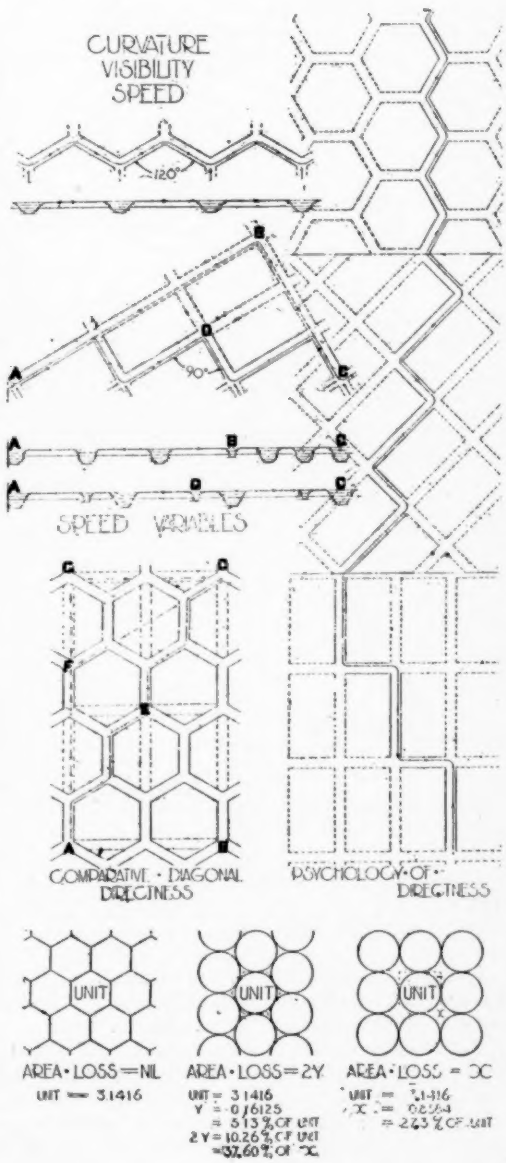
Desiderata.—An organic correlation of use, density and dimensions that will afford a normal interval of time-distance between home and work; that will afford health, efficiency and well-being. This implies design to purpose in function and limitation; our problem, if it is to remain all variables, will as such remain insoluble.

We must therefore, seek to determine self-contained urban units of balanced functional ratios and the most efficient and desirable assembly and interrelation of these.

Forces.—The forces of urban development are radial and circular and, seemingly, solution should be sought in approximation of the properties of circles—not in those of squares, the traditional attempt to fit square plugs into round holes.

The principle of hexagonal planning, traffic intercepter and orbit is submitted as affording a correlation of traffic that will obviate congestion and adjust environment to its human purpose, survival.

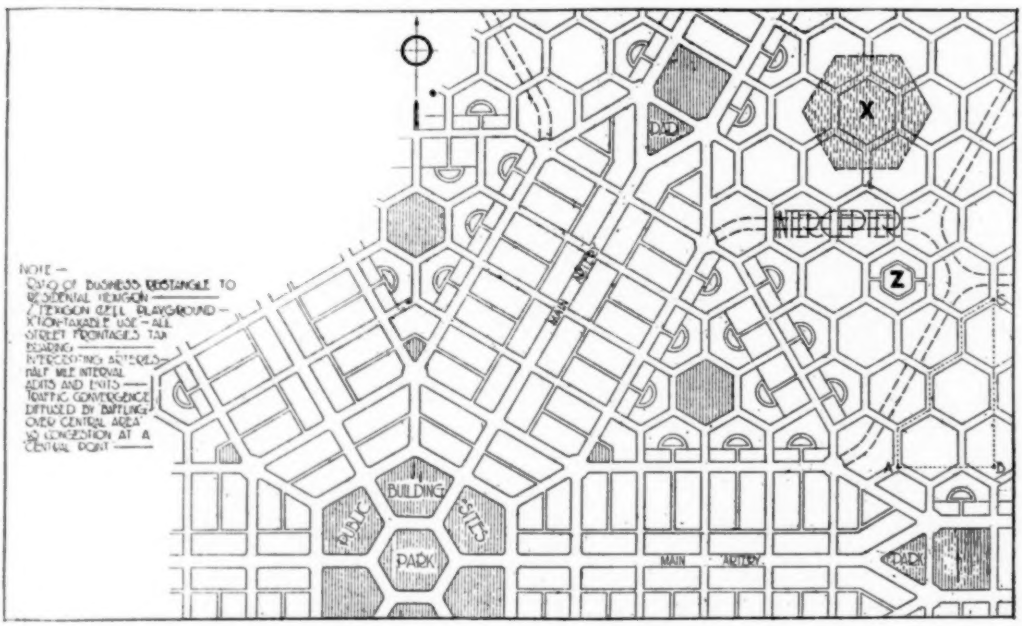
Forms.—The circle is the most economic boundry (or street) to any given area, as a



Derivation of Form

unit. Circular areas as units do not however assemble economically—they leave waste interstices. Allowing for flexibility and a measure of compression will, in practice, eliminate the wasteful interstices and develop the hexagon form in nearest approximation of the subdivision virtues of circles, yet free from their structural disabilities as streets. Below ground, sewers, mains, conduits, etc., must be built in straight sections, of operating necessity. Above ground, buildings, rectangular walls, etc., are more economic and advantageous to build in straight sections than curves.

A system of subdivision demands a pattern of units susceptible of continuous and indefinite contiguity without intersticial areas wasteful of local improvements and public services.



Schematic Diagram Illustrating Relative Balance of Cells to Arteries

Three Main Conditions.—To obviate congestion of traffic, and the many evils that come of it, there are three main conditions to be solved:—

1. The distribution of population in its homes, for which hexagonal planning is submitted as being most advantageous.
2. Transportation between home and work, for which the Intercepter affords the optimum time-distance.
3. Routing the process of "work," for which consider a correlated traffic orbit.

The Hexagon.—The hexagon unit block in hexagon pattern seems to best meet the requirements of a basic system and general pattern; viewing the major area of cities as residential hexagons; with ample latitude for specialized differential and rectangular design to purpose of business, commerce and industry.

Advantageous properties of the hexogonal residential block are:

A. Health, north pointed get universal access of sunshine and afford safety, rest, recreation and amenities for child, adult and community life.

B. Traffic, safety and acceleration, three-way wide angle of vision, street junction of three-collision points vs. sixteen in rectangular limited visibility crossings; collectively, total of eighteen to sixty-four collision points. Further, the street length around the equivalent rectangular block is 1,420 ft., i.e., an average collision point for every 22.19 ft., whilst the length around the hexagonal block is 1,284 ft., i.e., an average collision point only every 71.33 ft. of street length. Besides this there is 10 per cent less street length in the hexagonal street planning system.

C. Economy, fewer and shorter streets, less capitalization.

The psycological and actual properties of hexagonal planning may perhaps best be judged from the accompanying diagrams and their indications, noting correlated content and directness.

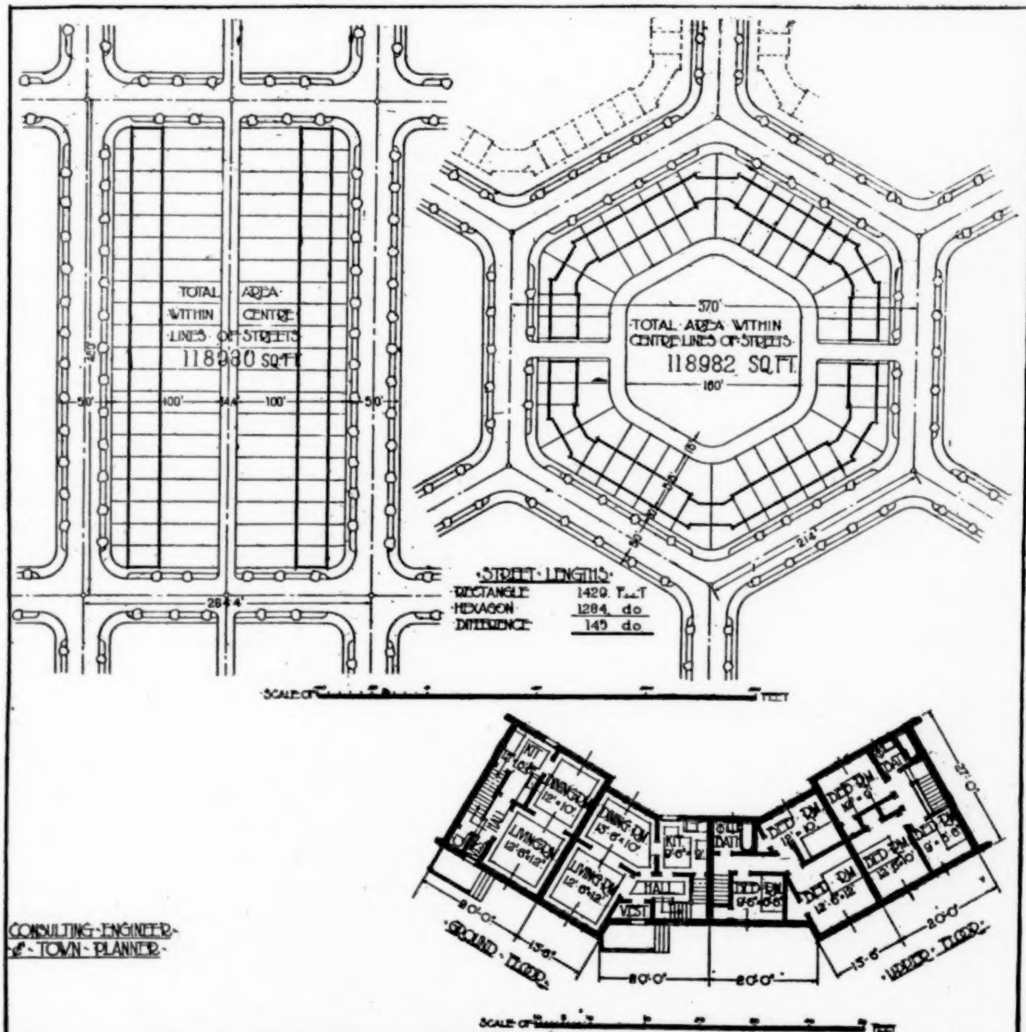
The Dominion postal authorities, at Ottawa,

have kindly given consideration and thought to the effects which hexagonal planning would have upon the delivery of mail, by letter carrier, upon post box collection by motor cycle and upon parcel delivery by truck. I am advised that the opinion of the men in these different services is that they would find no difficulty in adapting their "bump of locality" to the hexagonal system of subdivision.

Previous Use of Hexagon Block.—Mueller in Germany, about 1910 (?), advocated hexagon blocks assembled so as to leave all sides as continuous straight streets; but this left triangular interstices which were economically wasteful of bounding streets and public services.

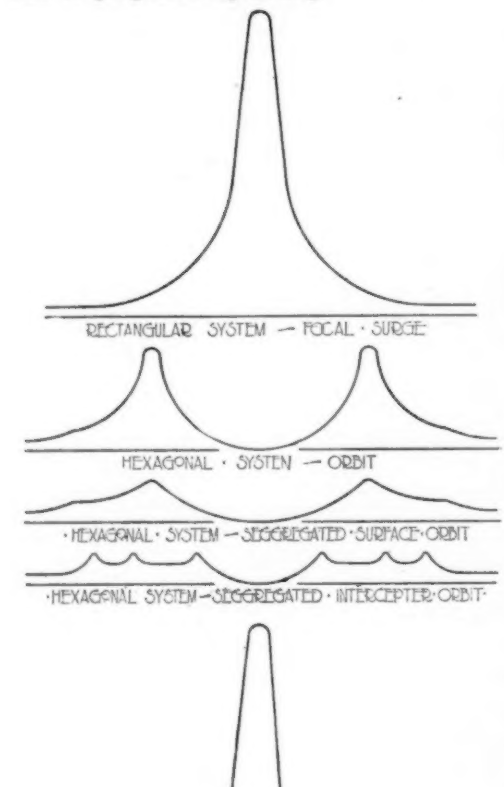
A. R. Sennett in England, in 1905 published a two volume work on town planning in which he advocated absolutely the rectangular circulatory system, even objecting strongly to the introduction of diagonals. He, however, advocated the subdivision of the rectangular blocks into lots on a hexagonal pattern, i.e., three rows of lots between streets, the centre row being small hexagons off centre to the street fronting lots, the object of this disposition being to allow of equal frontage ownership coupled with a choice of additional rear yard area for those who wished to take such allotments.

There are examples in Europe and America, the hexagonal system of main arteries of the



Comparative Land Development for Community Housing

1807 Governors' Plan of Detroit is our best example. The individual blocks in this Detroit plan are not hexagonal; they are rectangular and irregular and without any relation to advantageous orientation. But even with its limitations it has many advantages over the existing plans. Its abandonment was a great loss to progressive planning.



Obviation of Traffic Congestion: Comparative Traffic Sections

The adoption of a hexagonal block in basic pattern favors though not exclusively, the development of a hexagonal system of major arteries, both surface and intercepter.

The Intercepter.—The requirements of communication demand of a plan system and pattern that it offers the minimum average interval in time distance over a maximum area between home and work and within the sum of objectives; that is to say, that the streets, arteries and through transits should be so correlated that the tide of population and traffic may ebb and flow freely without congestion over the greatest possible area for a normal given time-distance of about one-half hour, or so much more as psychology and circumstances may demand as the turning point of amenity in free attractive, competitive areas and inducements to spread.

Our present arterial provisions are inadequate for expansion because they ultimately become choked by cumulative local traffic arteries calculated for an initial purpose cannot be widened from generation to generation as the process will eventuate in the logical absurdity of continually reducing the economic proportionate dimension and area of the business lot upon a thoroughfare of ever-increasing importance. Some new principle must be evolved for dealing more efficiently with the conditions of expansion which have come with modern civilization in greater speeds and vaster accumulations. That principle, I submit is the intercepter.

The intercepting artery is one which carries through traffic free from cumulative local traffic; it is an artery upon which no opening and traffic from facing property is allowed, and whilst denying accumulative access along its frontage. Nevertheless contributes open spaces for sunshine and air to the windows of that frontage. The adits and exits of such an intercepting artery should be placed at relatively long distances apart, as are stations upon a railway. It is recommended that the distances between the adits and exits of an intercepting artery be about ½ mile apart. A correlated system of environment can only be designed scientifically for given purpose and capacity. Accretion (laissez faire policy) beyond the designed given organic entity of correlated parts and functions (ratios of form and communications) will cause congestion and its disintegrating processes. Organic expansion beyond the initially designed capacity of the civic machine should be taken care of on the principle of satellite sub-centres. Inter-relations between the central area of attraction and its satellite sub-centres should be provided for by intercepters, i.e., rapid highways free from the accretions of local frontage access.

The factors of population density, as determined by zoning (use and bulk), and as provided for in capacity of width and cumulative length of streets and arteries with index of speed at which the population-shed can mobilize its fluid content, determine the time-distance radii of a normal civic entity. This should be the limit of the self-contained civic entity if it is to attain and retain the optimum in human, social and economic efficiency of the individual, in city and state.

Average straightness between the total of objectives may be summed up as general directness. Directness is also conditioned by visibility accelerating speed.

Further, there are factors of psychology in directness; the appearance vs. the reality.

Relief vs. Congestion.—The question of the cost of land required for intercepters and the cost of their construction is in principle answered by comparison, on its merits, in given circumstances, with the cost of congestion, where lack of width and freedom develop it. To relieve congestion by widenings, subways, viaducts, etc., makes it prohibitive as a general process.

Where the relief by widening, etc., is only local it frequently merely defeats its own ends by inducing a diversion of traffic to itself and renewing congestion, but to a more intense degree.

Individual surface diagonals by their more outstanding directness, where not part of an organic system, are also apt to develop congestion and contingent disabilities, though they are the lesser of two evils.

The Gridiron.—The Gridiron street system is a relic of primitive two-dimensional thinking, merely length and breadth, developing the illusion that from any street intersection in any area there is a straight way to all other objective points within the area.

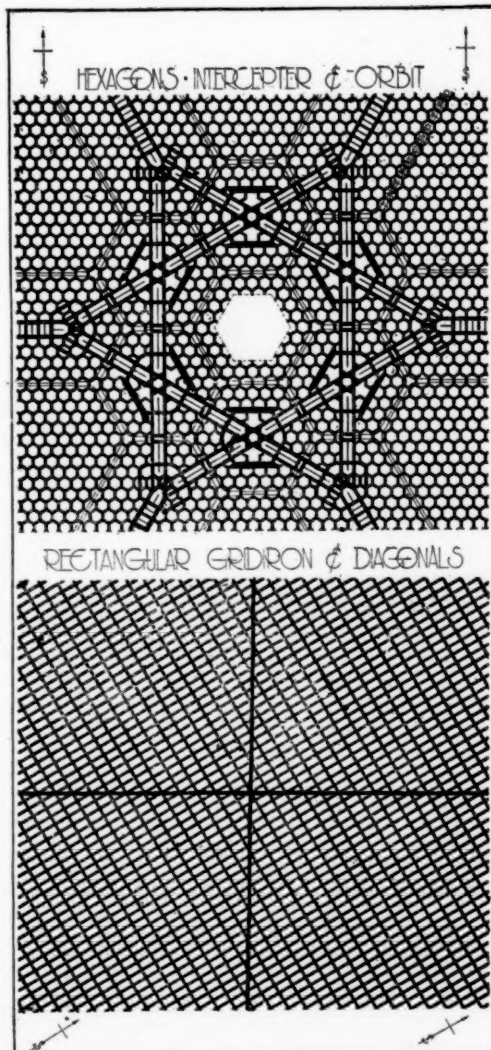
Whereas, the gridiron favors straight ways in merely two directions, whilst opposing the long way round of the two sides of a triangle to all others, the great majority of destinations.

The thoughtless license given to population density by heights abnormal to the channels of communication awakened engineers to a third dimension, volume, and very soon to recognize time, time-distance in speed and safety, as the fourth and the limiting one of capacity.

We must now seek a balanced correlation of forms and contents, of channels and speeds, the norm of entities and interrelations that will afford freedom from congestion; for congestion is the cancer of community progress.

Orbit.—In an accompanying schematic diagram a field of hexagonal residential blocks and streets is shown served by a twin system of surface arteries for local distribution and diffusion, circumscribing a large open central area. The mobilization of traffic throughout the population-shed is compensated and accelerates at vortex contacts between the local arteries and the through traffic intercepters.

This diagram of comparative circulation is to illustrate a theory that major arteries in converging, as they should, towards a central area, yet ought to diffuse far short of a central point; and that there should be a relatively large park-like inner central and pivotal area of low pressure; further that there would be engendered by a design of this nature a constant disposition to division and deflection of incoming and outgoing movements, estab-



Comparative Circulation for Hexagons, Intercepter and Orbit and for Rectangular Gridiron and Diagonals

lishing balanced centripetal and centrifugal mass movements of traffic that would set up a form of gravitational attraction swaying and converting the inevitable peaking of the focal surge of traffic into rotation on a well balanced orbit.*

*Compare comparative cross-sections of focal surge peak vs. gravitational orbit.

Street and Highway Safety

Report of National Conference at Washington, D. C.

The purposes which brought the National Conference on Street and Highway Safety into existence in the spring of 1924 have in part been accomplished, but very much remains to be done. These purposes were, first, to focus public attention on the appalling increase in street and highway accidents, and second, to develop a comprehensive program for improvement of traffic conditions and reduction of accidents, upon which all concerned, including state and municipal officials and others interested, could agree.

The losses of life, personal injuries and destruction of property in traffic accidents have been estimated at an economic loss of $600,000,000 annually, and additional losses resulting from congestion and other causes incident to inadequate traffic facilities bring the estimated total loss in the United States due to all these causes to more than $2,000,000,000 per annum.

The awakening of public consciousness is not only shown in the widespread attention which has been given to the subject throughout the country, but is also reflected in an apparently favorable change in the trend of the accident record, which, up to and including 1923 was mounting at a progressively increasing rate, but which in 1924 showed a much lower rate of increase. In many jurisdictions in 1925 the number of fatalities was kept down and in some cases reduced below the 1924 figures. The widespread publicity resulting from the Conference itself, and the work of the participating organizations and other interested groups, have had a marked influence in bringing to all classes of the population concerned a realization of their responsibilities in dealing with this problem. There is urgent need however, that this be translated into further remedial action.

Remedial Measures.—A program of specific remedial measures has been developed by the conference, first through the surveys carried on in 1924 by eight special committees dealing with the essential elements of the accident reduction problem and, second, through the supplementary committee reports prepared for the present conference.

For the benefit of states and committees having to deal with the problems of traffic and accident reduction, the conference desires to emphasize the continuing value of the reports rendered to the first conference by the following committees:

1. Committee on Statistics.
2. Committee on Traffic Control.
3. Committee on Construction and Engineering.
4. Committee on City Planning and Zoning.
5. Committee on Insurance.
6. Committee on Education.
7. Committee on the Motor Vehicle.
8. Committee on Public Relations.

These reports, with but slight changes, were adopted by the first conference, after thorough consideration, and summarized by the conference in its report of legislative principles, administrative and regulatory principles, and suggestions for cooperative work. The conference recommends that the reports of the committees of the first conference, and the report of that conference itself, be made available to all who have occasion to use them.

New Reports at Second Conference.—The committee work done in preparation for the second conference has been primarily designed to develop further and put in more available form the recommendations made by the first conference. The new reports include those of:

(a) The Commitee on Uniformity of Laws and Regulations, which presents a suggested model for a uniform vehicle code, developed with the cooperation of the National Conference of Commissioners on Uniform State Laws and dealing with registration, certificate of title, licensing of operators and chauffenrs, rules of the road, and regulations governing the operation of vehicles on highways, adequate signing of the highways, together with suggestions for the development of uniform municipal ordinances and uniform state and municipal regulations.

(b) The Commitee on Enforcement, which recommends measures of organization and procedure to secure better enforcement of the laws and regulations affecting street and highway safety.

(c) The Committee on Causes of Accidents, which gives such information as is available as to the causes of accidents and outlines a program for determining the causes of accidents with a view to their eliminations.

(d) The Committee on Metropolitan Traffic Facilities, which outlines a program for improvement of traffic facilities and recommends suitable plans of organization for its accomplishment.

(e) The Committee on Statistics, which presents essential facts of the accident record together with its recommendations as to im-

provement in the collection and analysis of accident statistics.

(f) The Commitee on Public Relations which proposes measures for putting into effect the recommendations of the Conference through action of the participating organizations.

After reviewing these reports the conference is of the opinion that, taken together with the reports of the 1924 conference mentioned above, they constitute a sufficiently complete program for present purposes, and that the program to which special attention should be directed is that of putting this program into effect.

The conference submits the following outline of its recommendations, the details of which are found in the reports of the commitees and in the report of the first conference.

Traffic Laws and Regulations.—A Uniform Vehicle Code, including, (1) A Uniform Motor Vehicle Registration and Certificate of Title Act, (2) A Uniform Vehicle Operators' and Chauffeurs' License Act, and (3) A Uniform Act Regulating the Operation of Vehicles on Highways, should be enacted by each of the states and the District of Columbia. A suggested model for such a code is contained in the report of the Committee on Uniformity of Laws and Regulations which, with modifications approved by the present Conference and embodied in Appendix A attached to this report, is endorsed by this Conference and is recommended to the National Conference of Commissioners on Uniform State Laws and to the several state legislatures as the basis for uniform legislation on the subject.

The Uniform Vehicle Code should be supplemented by state administrative regulations which should, as far as practicable, be developed on a uniform basis through cooperative action of the associations of officials concerned, particularly the state highway officials and motor vehicle commissioners, together with joint committees including other public officials, and representatives of automobile clubs, scientific organizations and commercial and other bodies concerned.

The Uniform Vehicle Code should further be supplemented by local traffic ordinances with regard to which progress toward uniformity should be sought through state or regional conferences of officials and other persons or organizations interested.

Local traffic ordinances should also be supplemented by the necessary detailed rules and regulations to be established by local authorities, and uniformity in such regulations should be secured through the associations of officials concerned, with the cooperation of other persons and organizations interested.

In view of the fact that fatal collisions of motor vehicles with pedestrians, already amounting to 60 per cent the total number of fatal traffic accidents, are increasing at a rate out of all proportion to the rate of increase in other traffic fatalities, the education and regulation of pedestrians as well as of drivers should be given greater attention than at present. Pedestrians and motorists should bear a considerate attitude each to the other. Along rural highways, wherever there are suitable sidewalks or paths pedestrians should use them. Where there are none, they can generally walk most safely on the left-hand side facing the traffic, having due regard to danger at curves, but should not force motor traffic out of line or otherwise impede it. In cities pedestrians should be instructed, urged and required to keep within the boundries of designated safety zones and crossing places and, when there is congestion, to cross only with the traffic. Motorists should be required to accord pedestrians safe and dignified use of such safety zones and crossing places. Pedestrians as well as motor vehicle operators should be required to obey the traffic rules and regulations and should be punished by adequate fines for failure to do so.

Additional legislative and administrative measures should be adopted as hereinafter recommended for enforcement of the traffic laws and regulations, public education in traffic safety, street and highway planning, construction and maintenance, railroad grade crossing protection and elimination, and other measures for improvement of the traffic situation.

Enforcement of Traffic Laws and Regulations.—State laws should prescribe a uniform system of enforcement to be applied in part by the state courts and administrative machinery and in part by the local authorities. The necessary special traffic control and traffic patrol police should be provided and the regular police should participate in traffic enforcement. Provision should be made for prompt and thorough collection of evidence and investigation of accidents; for special traffic courts or special traffic sessions of general courts, and traffic violations bureaus with a schedule of penalties for disposing of minor infractions, so as to give the courts more time to deal adequately with more serious cases; uniform permanent records of all convictions of traffic violations and of traffic accidents, suspensions and revocation of operators' license and refusals to grant licenses; and exchange of detailed information between jurisdictions as to suspensions and revocation of licenses and convictions for serious traffic offenses. Neither the traffic officers nor the court judges should receive any fees from the money collected from traffic convictions.

The courts and the police through vigorous enforcement and evenhanded treatment of offenders should instill in the public respect for the traffic laws and regulations.

Public opinion in support of enforcement should be organized through a representative citizens committee in each locality, forming part of an organized effort of all elements in the community interested in street and highway accident reduction.

Education.—Education in safety and accident prevention should be incorporated in the curricula of elementary schools, both public and private, parochial schools, night schools, vocational schools, citizenship schools and schools for non-English speaking adults, and should also be carried on through educational contests, organized playground training, school boy patrols, boy and girl scouts, and junior safety organizations. More advanced training in safety and traffic matters should be developed in secondary schools, normal schools for playground supervisors, engineering schools and universities, including training of traffic engineers.

A uniform manual should be compiled and distributed for the education of operators of motor vehicles in safe driving practices, divided into two sections, one comprising special instructions to drivers of commercial vehicles and the other special instructions to drivers of private passenger automobiles; and standardized plans should be further developed and put into operation for the education in safe driving and accident prevention of the employees of steam and electric railways, employees of taxicab and motor bus companies, and the drivers employed by operators of commercial vehicles.

Plans should be developed and put into operation for the education in safety of the general public through:

(a) Newspapers and magazine publicity—including the foreign language press.
(b) Posters in public places.
(c) Motion pictures and lantern slides.
(d) Radio talks.
(e) Schools for motorists including both men and women.
(f) Safe drivers clubs.
(g) Safety programs or addresses at meetings of various organizations.
(h) The Churches.
(i) Mass meetings.
(j) Plans for reaching parents through school children.
(k) Special campaigns.

Standardized plans should be developed for the selection and training of traffic officers and such plans should be put into operation by all communities either alone or in cooperation with other communities, or on a statewide basis, so that the benefits of such training may be available to the smaller communities.

Statistics.—To promote a better understanding of the traffic accident problem and the measures which should be taken for the elimination of accidents, accurate, complete and up to date statistical information should be secured by the duly authorized state or in large municipalities, by municipal officials regarding all traffic accidents, with standard definitions of terms and reasonable uniformity in reporting and tabulating schedules, under the following headings:

(a) Location (place and position.)
(b) Time (Hour).
(c) Type of accident.
(d) Weather.
(e) Road conditions.
(f) Lighting conditions. (street)
(g) Physical condition of persons involved.
(h) Experience of driver.
(i) Age and sex of driver.
(j) Relation of driver to car owenership.
(k) Mental condition of driver.
(l) What was the driver doing.
(m) Condition of car or cars at time of accident.
(n) Speed of car or cars.
(o) Primary cause of accident.
(p) Contributing causes or circumstances of accident.
(q) Violation of traffic ordinances or M. V. laws.
(r) Age and sex of injured.
(s) Extent and character of injuries.
(t) Character and amount of property damages.
(u) Preventive safeguards recommended.

The information secured should be analyzed, and the summarized results published promptly and frequently. Accident spot maps should be maintained to detect those points at which accidents occur most frequently and to form the basis for plans to eliminate the conditions which cause accidents.

To promote popular understanding and attention to the accident problem and stimulate competition between various communities in accident reduction, a comparative index rating of all the states and communities should be set up through the Bureau of the Census with the cooperation of the organizations concerned.

A contest in accident reduction based on (a) the performance of each state or community for each year as compared with its previous record, (b) the adoption of measures recommended by this Conference for improvement of traffic control and enforcement, and (c) the provision of improved traffic facilities, is recommended to such organization or organizations as may be able to undertake such a contest.

Causes of Accidents.—A comprehensive program of research into the causes of street and highway accidents should be undertaken by a national body qualified for the purpose with the cooperation of other organizations interested with a view to determining the direct and contributing causes of accidents and the frequency of the various hazards, and with a view to pointing the way to the improvements from the standpoint of safety in design, construction or adjustment of motor vehicles; design, construction or maintenance of streets and highways; traffic laws, regulations, systems, signs and signals; and methods of examining applicants for operators' licenses, including special examinations for professional drivers, persons suffering from physical or mental handicap, and persons who may be brought before the courts or motor vehicle commissioners for repeated traffic violations.

Design and Maintenance of Motor Vehicles.—Continued effort on the part of manufacturers is urged with a view to improving further the design and construction of motor vehicles and accessories from the safety standpoint with particular reference to proper road illumination without dangerous glare; construction and location of controls, accelerator and brake pedals to minimize possibility of confusion or uncertainty of application by the driver; greater certainty, durability and readiness of adjustment of brakes; improvement of driver's vision; and other safety features.

A simple and practical inspection chart and code applicable to all makes of motor vehicles giving particular attention to items affecting safety should be prepared and issued through the Department of Commerce; and public authorities having supervision of motor vehicles carrying passengers and freight for hire should require adequate inspection and upkeep of such vehicles.

Street and Highway Traffic Facilities.—A comprehensive traffic improvement program, including urgent immediate items and long time items, should be undertaken in every community or metropolitan area confronted with a traffic problem. In the preparation of such a program due consideration should be given to the relation of costs to benefits in safety and acceleration of traffic and the program should be properly worked out and budgeted.

The traffic improvement program should be based on a thorough traffic survey giving the necessary physical and traffic data and kept up-to-date, and due attention should be given to city and regional planning and zoning in their effect on traffic. The program should include:

(a) A transit plan, covering facilities for the mass movement of population by vehicles of all classes, including rapid transit, steam railroad commuter service, street car lines, bus lines, private automobiles and other means.

(b) A street and highway plan, providing for main thoroughfares, by-pass and interconnecting thoroughfares, secondary streets, business and industrial streets, and local residence streets, with any necessary enlargements or improvements required to carry the traffic with expedition and safety.

(c) A traffic control plan, to provide for the orderly improvement of facilities and measures for the safe, efficient, and complete utilization of street and highway capacity.

A sound financial program should be established which will insure properly balanced progress in such improvements and will properly distribute the burden of providing the necessary funds.

To insure proper planning of traffic facilities and traffic control, to assure cooperation of the different departments of city or local governments concerned and to enlist public support, a traffic planning organization should be created in each city or metropolitan area as follows:

(a) In each city there should be an official traffic commission, including such officials as the chief of police, city engineer, engineer of the city plan commission, chief of the city fire department, a representative of the public authority supervising city transit and transportation, a member of the city council, and a representative of the city's legal department. This commission should be a permanent body having the services of an engineering staff preferably in charge of a trained traffic engineer, and should prepare a comprehensive traffic plan, make and keep up-to-date a traffic survey, and recommend a traffic ordinance and regulations or recommend from time to time any necessary modifications in the existing ordinance and regulations.

(b) It will also be of value to have traffic committee not made up of officials but including representatives of street railway companies, motor bus companies, taxicab companies, trucking organizations, chambers of commerce, automobile clubs and associations, safety councils, merchants' associations and other interested groups. The traffic committee should serve in an advisory capacity to the traffic commission and assist in securing the interest and support of various representative organizations and the public generally. If there is no traffic commission the traffic committee may temporarily carry out the functions of both bodies.

(c) In the improvement of main highways leading to and from large centers of population it is frequently found that administrative jurisdiction over various sections of the road is divided among municipal, county, state and even national authorities. In such cases prac-

tical results in relieving traffic congestion will usually be obtained most quickly by voluntary cooperation between the authorities concerned through the creation of joint boards to consider and determine policies of location, construction, maintenance and use of the highways.

(d) To provide unified consideration and treatment of traffic problems in metropolitan areas which include more than one city or a city and politically independent suburbs, it will generally be necessary to depend upon an enlargement of the unofficial traffic committee of the central city by adding proper representative of important suburban communities, or in the case of two large cities in a single metropolitan area, to form a joint traffic committee with representatives of suburban communities added. When developments warrant, an official metropolitan authority should be created to control physical growth, and provide for proper traffic facilities within large population centers.

In street and highway construction attention should be given to adequate roadway width with provisions for pedestrians, adequate rights of way to provide for parking space, for clear view at curves and intersections and for future roadway widening; space for parking off the traveled portion of rural highways, either continuously or at intervals not exceeding 300 feet; reasonable grades of not more than six per cent where feasible on thoroughfares of primary importance; curves of not less than 200 feet radius on highways of primary importance; curves widened and banked; no combination of heavy grades and sharp curves; adequate curb radii and smooth grades at street intersections; cross-sections of the pavement or roadway as flat as drainage conditions will permit guard railings of substantial type on the shoulder of embankments; clear view of approaching vehicles for at least 300 feet on highways of primary importance, with necessary control of private advertising signs on the right-of-way or upon private property near the highway; removing of trees, shrubs and sloping banks on or off the right-of-way at curves and intersections, and cutting down of sharp hillcrests; bridges at least 22 feet wide, to enable two lines of taffic to pass without difficulty, and suitable provision for the safety of pedestrians on such bridges; careful selection and clear marking of detours and maintenance thereof in safe condition; maintenance in good condition of pavements and roadway shoulders; prompt snow removal from streets and highways of heavy traffic; proper signs, signals and highway surface markings on a uniform basis and proper illumination of city streets and of state highways wherever financially practicable.

Adequate playgrounds throughout the community should be provided and particularly there should be available a playground for every school as a safety measure to keep the children off the streets. Schools and playgrounds should, as far as practicable, be so located that children will not have to cross busy traffic streets in going to and from them. Adequate provision for skating and coasting, where practicable, should be made in parks and playgrounds, properly lighted and supervised, or on streets set apart safely marked and traffic controlled, during hours used for these purposes.

Elimination and Protection of Grade Crossings.—Elimination of grade crossings, either by relocation of highways or rail lines or by grade separation which constitutes the only perfect solution of the problem, should be carried on under a proper program, first eliminating the most dangerous crossings on thoroughfares carrying heavy traffic, and with due recognition of the enormous costs involved which, if elimination were attempted on a wholesale scale, would impose an excessive financial burden resting in the last analysis upon the public. The program should have due regard to the relative costs and advantages of grade crossings elimination and other methods of protection, and should be given the most thorough joint consideration by proper authority. In laying out new highways or railroads, or relocating existing highways or railroads, grade crossings should be avoided or eliminated whenever feasible. In eliminating grade crossings narrow or obstructed underpasses and sharp turns in the approaches thereto should be avoided. Authority to order grade separations or proper protection at grade crossings should be vested in the commission having jurisdiction over the railways and this commission should also determine the proper division of costs between the railroads and the public. The states highway department or other highway authorities should plan the improvement and initiate the proceedings for all highways under its jurisdiction. Time is an essential element and a prompt decision should be provided for in the law.

Railroad crossings remaining at grade should be safeguarded in every reasonable way. Standard warning signs and pavement markings should be used to clearly mark the approaches to all public railroad crossings. Where the volume of traffic requires it additional protection should be afforded by the use of flag men, gates or approved electric or mechanical devices standardized as far as practicable. So far as possible a clear view along the track in both directions from both sides thereof should be maintained. The placing of railroad cars near unprotected grade crossings so that the view is thereby obstructed should be discouraged.

Highway Transportation and Railways

Relation of the Two Discussed in Paper Presented April 14 at Spring Meeting of American Society of Civil Engineers

By RALPH BUDD
President, Great Northern Railway

That most phenomenal of all industrial developments, the automobile industry, is the youngest, and now is said to be the largest, in the United States. It is barely 25 years old. Its importance is so great, taken as a whole, that the railways gain much more from the freight traffic it gives them than they lose from the freight and passenger business it takes away.

Like all great developments, that of motor travel has been the result of a combination of favorable circumstances. Most important were the perfection of the gasoline engine and the paved highway. Added to these is the fact that in America there is a standard of living so high that luxuries are not beyond the reach of the many. Each of these conditions is partly the cause and partly the consequence of the others. Eighty-three per cent of all the automobiles in the world are in this country, which has about 7 per cent of the world's population. We produce even more than we use, but it is a mistake to think that the automobile is something which we originated and that it always has been peculiarly our own. Before the manufacture of automobiles was of any importance in the United States, they were in more or less common use in England and on the Continent, and had reached a much higher state of perfection there than here. It was not until about 1905 that the number of cars in the United States exceeded the number in Great Britain. There was comparatively little improved highway in this country then, but we had magnificent distances which afforded an opportunity for the automobile to attain its fullest capabilities. Moreover, the great individual purchasing power of our population constituted a potential demand which required only the encouragement of reasonably priced, reliable cars and better highways to burst into actuality. The volume of this demand made quantity production possible and brought the low priced car, together with a program of general highway improvement throughout the country. The almost universal ownership of the automobile which has resulted demonstrates the fact that when the public finds something it approves of and desires, its response is quick and emphatic. The new contenders for local freight and passenger traffic, the motor truck and bus, are outgrowths of the automobile.

Why the Motor Bus?—Probably the questions most commonly asked by railway men concerning the motor bus, are "What can its attraction be?" and "Is it not a fad which soon will lose its novelty and disappear?" Let us consider these questions. In many localities the bus does have some advantages over the railway train for local travel. Two of these are the greater frequency and the flexibility of its service. Compared with the railway train, the bus can give service at more frequent intervals, because each unit of service is small and may be operated cheaply in comparison with the cost of operating a train.

The ratio of cost of highway bus to steam train operation is about one to five, which means that for the cost of one train in each direction, say morning and evening, a bus can be run every two hours in each direction from 8:00 a. m. to 4:00 p. m., and this more frequent service better suits the needs of the average rural community. Owing to the extensive use of the private automobile there is scarcely enough travel even morning and evening on the average local run to justify a train, much less to justify several trains during the day; but the smaller and less expensive motor bus operating on the highway may pick up sufficient traffic to make it profitable. Besides greater frequency, there is the advantage of more convenient starting and stopping places. The motor bus is able to take on and discharge passengers at any street corner or at any house along the road. In other words, the motor bus is able to give a more flexible service than the train. People in the country can hardly use the railway for travel between neighboring stations, because, in proportion to the whole journey, the trips to and from the stations are so long. Not so with the bus. It gives continuous service all along the highway, while the railway gives it only at points four to six miles apart. Now, the amount of this strictly local business which railways cannot handle is considerable, and may be enough to insure the success of bus transportation.

Rail motor cars are being used rather extensively in lieu of steam passenger trains. They provide a unit of more suitable size, and

economize by substituting the internal combustion engine for the steam locomotive, as well as in other ways. About five hundred such cars of various types are in service, and the cost per mile for operation is about one-third the cost of running a passenger train. They are successful, therefore, to that extent, but are subject to the inherent limitations of any vehicle operating on railroad right of way. They cannot get as much "pickup" business as buses, which run along the highways and streets, and stop at houses, stores, offices, hotels, and any other desired place. The special field for the rail motor car is to take the place of the steam train on light traffic runs, such as branches and local and suburban districts where, for various reasons, service must be provided.

The radius of travel of an individual multiplies many times when he bocomes the owner of an automobile. His sense of independence and freedom, and his ability to give himself and family enjoyment not otherwise obtainable are sufficient reasons for sacrifices, if necessary, in other directions in order to have a car. For short distance travel the most ideal way yet devised is by the private automobile. This is an important truth, because it accounts for most of the development in motor bus transportation and most of the railways' loss of passenger traffic. For those who do not have their own automobiles, or having them, prefer occa-

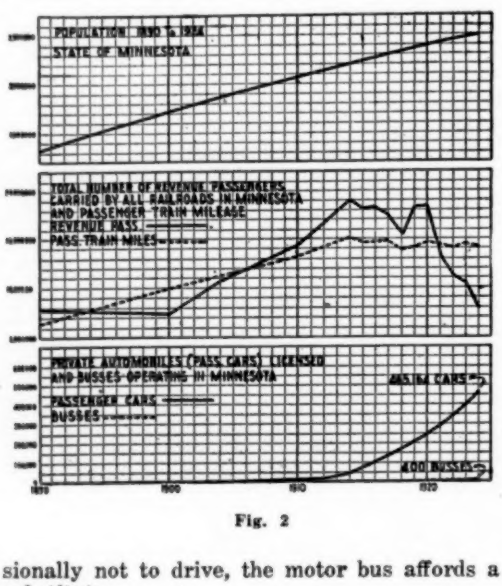


Fig. 2

sionally not to drive, the motor bus affords a substitute.

The congestion of city streets has become a serious problem for the automobile user. In all cities, during the busiest hours of the day, much of the advantage of the automobile is lost for lack of parking space on the streets. This problem is having attention, and doubtless to some extent it will be solved by providing convenient places for parking cars near business centers. The cost of such parking, however, will influence some private car users to avoid the congested centers. In very large cities the bulk of commutation travel probably can be handled only by railway trains, subways, and elevated lines, but there seem to be

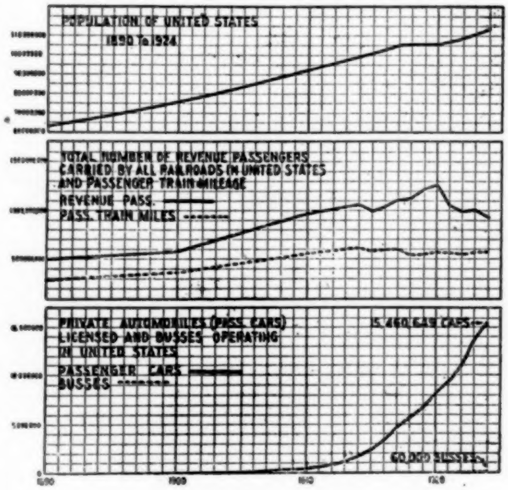


Fig. 1

many cities where the street congestion is not too great for motor buses, yet is too great for private cars to operate conveniently, comfortably and economically. In such places the motor bus has positive advantages.

The Automobile and Local Travel.—In connection with these questions of frequency and flexibility of service, which are the main advantages of local highway over local railway passenger service, let us consider whether the railways really lost their business to motor buses or to private automobiles. Statements submitted to the Minnesota Railroad and Warehouse Commission recently indicate that the railways in Minnesota had lost a substantial part of their local passenger traffice before motor buses began operating to any extent, and that the number of automobiles continued to increase as the number of passengers carried by railways declined; also that at stations where motor buses have been operating for some time, the loss of passenger business has not been materially greater than at stations where they have never operated.

I submit, as Figure 1, a chart showing passengers handled by the railways in Minnesota since 1890, passenger train miles, automobiles and buses in Minnesota, and population; as Figure 2, similar information for the

Table I.—Record of Tickets sold in the years 1920 and 1924 at Fifteen Stations in Minnesota where there was no Bus Competition.

	No. of Tickets Sold			
Station	1920	1924	Decrease	PerCent
Benson	35,371	11,557	23,814	67%
Browns Valley	5,882	1,773	4,109	70%
Clara City	7,665	2,420	5,245	68%
Cottonwood	7,371	2,393	4,978	68%
Granite Falls	16,680	5,583	11,097	67%
Hallock	10.569	5,345	5,224	49%
Hanley Falls	10,925	3,011	7,914	72%
Herman	8,196	3,099	5,097	62%
Monticello	12,924	4,600	8,324	64%
Ruthton	5,790	1,722	4,068	70%
Warren	16,844	7,739	9,105	54%
Ortonville	2,743	1,005	1,738	63%
Odessa	272	66	206	76%
Appleton	10,562	3,268	7,294	69%
Milan	312	115	197	63%
Total	152,106	53,696	98,410	64.6%

Similar Record at Eleven Stations where there was Bus Competition.

Alexandria	37,398	15,429	21,969	59%
Delano	11,376	2,909	8,467	74%
Evansville	10,491	3,153	7,338	70%
Fergus Falls	59,422	26,868	32,554	55%
Jasper	12,624	4,460	8,164	65%
Litchfield	38,094	10,310	27,784	73%
Marshall	27,312	10,658	16,654	61%
Osakis	14,790	4,184	10,606	72%
Park Rapids	13,459	5,612	7,847	58%
Sauk Center	35,244	10,519	24,725	70%
Willmar	76,333	27,908	48,425	63%
Total	336,543	122,010	214,533	63.7%
Grand Total	488,649	175,706	312,943	64%

United States; and as Table 1, a tabulation of ticket sales at 26 railway stations in Minnesota. At 15 stations, where there was no bus competition, the decrease in passenger tickets sold in 1924 compared with 1920 was from 49 per cent to 76 per cent, with an average of 64.6 per cent. At 11 others, where there was bus competition, the decrease was from 55 per cent to 74 per cent, with an average of 63.7 per cent. The total number of tickets sold at the 26 stations in 1920 was 488,649, and in 1924 was 175,706, a decrease of 312,943, or 64 per cent. During the five years 1919 to 1924 the total number of passengers handled by the railways in Minnesota decreased from 18,274,516 to 7,905,378, or 56.7 per cent; while passenger train miles on these railways increased from 14,052,547 to 14,223,456, or 1.2 per cent; and the number of motor vehicles in the state increased from 259,741 to 503,437 or 93.8 per cent. Compared with 1919 the year 1921 shows a decrease of 4,902,444, or 26.8 per cent in railway passengers; an increase of 535,584, or 3.8 per cent in passenger train miles; and an increase of about 60,000, or 25 per cent, in automobiles, while buses had not yet become a factor. These and other data point to the conclusion that the private automobile has had a great deal more to do with the loss of railway passenger business in Minnesota than the motor bus. They also suggest and railway statistics support the suspicion, that before bus operation began, the local passenger traffic of the railways in Minnesota had decreased to a point where much of it was being done at a loss, largely because passenger train miles had not been correspondingly reduced. Manifestly, the taking off of passenger trains in such instances is justified. Every train that is removed, however, serves to increase the advantage of the competitor on the highways; but if the business disappeared while the railway service was maintained, there is hardly reason for continuing such trains. Whatever may be the various reasons, local travel, to a very large extent, has left the railway train for the automobile and bus. This patronage of buses seems to establish beyond any doubt that they will continue, and probably will increase in number. From the foregoing it seems clear that the railways must recognize that public necessity and convenience require the development of transportation upon the highways; that they should not attempt by arbitrary means to eliminate motor vehicle competition and should only insist that such competition be subpect to proper public control; and further that they should seriously consider whether or not this new form of transportation, from the public as well as their own point of view, cannot be more advantageously conducted under railway direction than otherwise.

Regulation.—The rapid development of the common carrier motor vehicle, especially as embodied in the bus, has resulted in the enactment of regulatory measures by 37 states of the Union. Similar measures are under consideration by legislative bodies of other states. The important and main provisions of these regulatory acts grant to the state the power to determine whether or not common carrier motor vehicles should be permitted to operate. If the state regulatory body is of the opinion that the public interests demand the operation of such motor vehicle service, it issues a certificate therefor which is commonly called a "certificate of public convenience and necessity." No operation of common carrier motor vehicle can be carried on in these states without obtaining such a certificate. These laws

1. Require an adequate bond to protect the traveling public,
2. Require state control of rate charged,
3. Require state control of schedules of operation,
4. Prohibit discrimination between individuals and communities,
5. Require safety of operation with reference to the type of vehicle, and in other details affecting the safety of the traveling public.

These acts grant to the state regulatory boards the same control in general which these boards exercise over railway carriers. The regulatory board is required to give consideration to the effect the proposed service may have upon other carriers, whether those carriers be railways or other motor vehicle carriers.

These regulatory acts are wholesome and were necessary. Without such regulation the public had no protection from socalled "fly-by-night" operators, who had no capital and who were unable to furnish adequate service. These irresponsible operators would come and go as the seasonal business might permit. That made it impossible for the legitimate operator to make reasonable profits and maintain adequate service. Sound regulation is building up in the several states of the Union a fixed and dependable service, and one which, in coordination with the railway service in these states, gives to the public the best conceivable local transportation. The rates which the bus companies are permitted to charge in general bear a fair relation to the railway rates, and are generally only a fraction of a cent per passenger mile less than railway fares.

The states have no power to forbid the operation of interstate carriers and have very little regulatory power over them. The Supreme Court of the United States has held that a state law which prohibits common carriers for hire from using the highways by auto vehicles between fixed termini or over regular routes without having obtained from the Director of Public Works a certificate declaring that public convenience and necessity require such operation, is primarily not a regulation to secure safety on highways, or to conserve them, but a prohibition of competition; and, as applied to one desirous of using the highways as a common carrier of passengers and express purely in interstate commerce, is a violation of the commerce clause, besides defeating the purpose expressed in acts of Congress giving Federal aid for construction of interstate highways. Prior to this decision, many of the states were regulating interstate carriers.

Truck and bus operators of the nation engaged in interstate commerce recognize that Federal regulation sooner or later is inevitable. But the Federal government, in regulating the interstate motor carriers, should leave that regulation, so far as the Constitution will permit, to the Commissions of the interested states. About 75 per cent of the railway business is interstate, and therefore the regulatory power of the railways is properly vested in the Federal government. The truck and bus business, by its nature, always will remain largely a local problem. Perhaps as much as 90 per cent of the truck and bus transportation of the country always will be intrastate. Those vehicles travel highways which were built by the state, and are policed and maintained by the state. It is, therefore, most proper that the power that regulates be delegated to the several states as far as practicable.

The Congress has now under consideration a bill regulating interstate motor vehicle transportation. Its main features are as follows:

> No common carrier truck or bus can be operated in interstate commerce without obtaining a certificate of public convenience and necessity therefor.
>
> This certificate is to be obtained from a joint Board composed of representatives from the several states in which the applicant proposes to operate. An appeal from the decision of the Joint Board so created, lies to the Interstate Commerce Commission.
>
> The Joint Board has complete power to regulate the service and rates and safety of operation of such motor vehicles. The bill drawn is intended not to hinder or hamper the development of common carrier transportation upon the highways, but to protect the legitimate operator thereon. It recognizes as a fundamental principle that common carrier transportation service must be in the hands of a responsible operator and that he should be protected from the irresponsible and casual operator.

The necessity of Federal regulation in the large states of the Union is not acute for the reason that nearly all of such carriers are engaged in intrastate transportation and are subject to the regulation of the state. However, where these transportation companies are operating in the smaller states and it is possible to cross state lines in a normal day's operation, the necessity of Federal regulation is apparent. The public cannot be adequately protected unless the Federal government enacts legislation that will require the operating company to furnish security for damage to persons or property, and unless the service and rates of such operators are fixed and determined through public authority.

The proponents of the bill have agreed that is should provide that operating companies, which were in operation on March 1, 1925, should, as a matter of course, without further proof of public convenience and necessity, receive a certificate.

Taxation.—Every user of facilities furnished by the state should pay reasonable compensation for the use thereof, especially when such facilities are used for private gain. Common carrier motor vehicles should pay a fair and reasonable tax for the use of the highways,

but regulation should not be attempted through taxation. By this I mean that taxes should not influence the granting of permission to operate, and that they should not be burdensome to the point of preventing low fares.

A highway is constructed for the benefit of society as a whole. Society, in the aggregate, benefits whether or not each individual may or may not use the highway. It has never been the policy of a state to charge the entire cost of upkeep of the highway to the users thereof. The highways are used by private individuals in the transaction of their private business for profit. They are used also by those who travel for pleasure, and they are used by common carrier transportation companies. Those individuals who choose not to drive their own cars, but who ride in common carrier motor vehicles, should not be asked to bear an unfair share of the burden of upkeep of the highways, nor should they be deprived of the advantage of cheap transport as inevitably must happen if public motor vehicles are taxed unduly, resulting in higher fares.

There are about as many different methods of taxing common carrier motor vehicles as there are states in the Union. Some states tax these vehicles solely on the basis of value or cost, some on a percentage of the gross revenue received, some on weight plus a fraction of a cent per passenger mile, and some on the seating capacity of the vehicle, or on the horsepower, or so much per hundred pounds of weight, or a combination of all. In addition to these forms of taxation, nearly every state in the Union has a per gallon gasoline tax. This tax amounts to about one-third of a cent per mile for the common carrier motor vehicle. Speaking generally, the taxes paid by buses, I believe, are fair and just. In Minnesota the tax is based upon the value of the vehicle. The parlor car type of bus in common use in Minnesota casts from $10,000 to $11,000. The annual tax paid on each vehicle is ten per cent on cost for the first year, decreasing ten per cent per annum to a minimum of $350. The average for the modern bus is about $750. The average annual tax paid on a Ford car is $12. It thus appears that the annual tax on a bus is about 60 times that on a Ford car. In addition to this, a tax of 2c per gallon is paid upon each gallon of gasoline used. I am advised that the tax paid by the bus companies in Minnesota is between 6 and 7 per cent of the gross earnings of the operating companies. The tax on gross railway revenue in that state is 5 per cent.

The annual tax upon a standard parlor car bus of a seating capacity of 30 passengers, weighing approximately 10,000 lbs, and costing $10,000, would vary in the different states from $150 per bus per year to $1,000 per bus per year.

Commercial highway users themselves have taken an active part in forming an enlightened public opinion on the questions of regulation and taxation. In January of this year the Motor Vehicle Conference Committee published, among other things, the following:

1. Sound and Equitable Principles for Intra-State Regulation,
2. Recommended Restrictions on Motor Vehicle Sizes, Weights and Speeds,
3. Sound and Equitable Principles to Control Special Taxation for Motor Vehicles.

One may not agree with the details of these recommendations, but it must be conceded that the free unrestricted use of the highways by commercial vehicles in competition with the railways is a thing of the past, and that the operators themselves recognize the desirability of having their use of the highways controlled by appropriate laws rationally administered.

Whether a railway company itself should own and manage buses may depend upon its willingness or unwillingness to take on additional obligations and responsibilities; but if no prejudice exists against bus operation, the deciding question probably will be whether, by such control, wasteful duplication can be eliminated and the service improved. There have been instances where, by coordinating the schedules, bus service has supplemented train service, to the end that for a lesser total expenditure a more complete and satisfactory service has been rendered. Each case is one for individual consideration. In many places throughout the United States electric lines have abandoned all or part of their tracks, and substituted bus service. In other cases, notably in New England, steam roads have substituted buses and trucks for branch lines.

The National Automobile Chamber of Commerce has compiled a census of bus operation as of January 1, 1926. Of 28,145 common carrier buses reported, 5,462, or 19.4 per cent, were owned by steam or electric railways. The number of non-common carrier buses reported was 29,605. They are used by hotels, industries, schools, and for sight-seeing and depot transfer. The geographical distribution of the buses reported is general. Of common carriers, the largest number in any state was 2,672 in New York, while Wyoming reported only 58. Ohio, with 2,454, had the most non-common carriers, while eleven for Rhode Island was the least reported by any state.

Cost of Bus Operation.—The question of cost of operating buses is vital for the future of that form of transportation, but reliable

records have not been kept long enough to establish what might be called normal costs for certain routes or localities, as in the case with transportation costs on the different divisions of railway systems.

The Railway Age, in its issue of March 27, 1926, published an article entitled "What Does it Cost to Operate Buses and Trucks?" in which detailed estimates of the cost of operating a city type bus in New York are given. These costs vary from 23.6 to 30.6 ct. per bus mile, depending upon whether the bus averages 200 or 100 miles per day. I have examined the details of these estimates and compared them with cost data, with which I am familiar, and I believe they are as reliable as can be made at this time, taking into account the fact that local conditions will determine several of the items in any such estimate. But the cost of bus operation should be at least 15 per cent less than it is, and unless it is reduced that much the business will not grow to its full possibilities.

The bus has come a long way from its origin in the motor truck, but it is not perfected yet. The March 15, 1926, issue of The Commercial Car Journal lists the different makes and types of motor bus chassis designed exclusively for passenger transportation. In this list are shown 96 types put out by 46 manufacturers. Standardization should result in substantial reduction in first cost, and the lessening of obsolescence would reduce the amortization or depreciation charges. The items of oil and gasoline and tires, of course, automatically would come down if a car weighing 9,000 lbs. could be substituted for one weighing 12,000. Cost of insurance also will be less as the business is stabilized. With lower costs, rates can be reduced and travel increased. I believe a good many people living along bus routes will take buses to town instead of driving their own cars, especially if the fare is low enough. Here is an opportunity to render a service to rural communities, and I believe it is a logical development in rural transportation for the bus to take the place of the private car on many occasions.

The Motor Truck—There are about 2,500,000 motor trucks in the United States. About 95 per cent of them are non-common carriers, and are not subject to regulation as to rates of service. They are successors of the horse-drawn warehouse, transfer and delivery vehicles, and of the farm wagon, but the motor has given them radii of operation many times those of their predecessors. In freight, as in passenger business, the railway is supreme in the long distance field. It is also supreme in the handling of the great volume of bulk commodities, such as coal, ore and grain. Indeed, there is nothing in the records of truck transportation to indicate that trucks are or can be contenders for any railway freight, except where the convenience of direct door-to-door delivery, together with the saving of terminal trucking and handling, outweigh the extra ton mile cost of moving freight by truck on the highway over the ton mile cost of railway line haul.

The principles governing the regulation and taxation of commercial freight carriers on highways are similar to those governing buses, but the handling of freight is so different from the handling of passengers that the truck bears a relationship to railroad freight service different from that of the bus to railroad passenger service. Freight shippers are interested solely in dependable, prompt and cheap transport, whether the shipment be over a long or a short distance. The charge for freight service is important, but the question of economy does not enter into the vast bulk of local passenger travel which moves by private automobile. The flexibility and elasticity of truck operation; that is, its ability to make door-to-door delivery and to give radial service to both rural and urban communities, gives it a large field of activity. The elimination of one or two handlings and the consequent saving in time amounts to more than the excess cost of road haul by truck over that by rail up to some undetermined distance beyond the terminal. What that distance is no one knows. So many variables enter into the problem, such as the amount of freight available on a given route, the character of the commodities, the relative importance of direct delivery to store doors, the extent to which return loading is obtainable, climatic conditions, the condition of the highways, etc., that only actual experience can determine how far beyond the city in each instance the truck can take the place of the box car. The horse-drawn truck excels the motor truck only for such freight as involves short movement and long delay in loading and unloading; the motor truck similarly excels the railway only where the distance involved is short enough so that the saving and convenience in terminal cost and handling offset the higher cost of transit by highway over railway, and only for comparatively small units of freight.

Common carrier trucks should not be permitted to operate in competition with railways except where there is a real public convenience or necessity. The convenience of a few in obtaining a quick delivery of property should not be controlling. It is most important that regulatory bodies, before granting a certificate for the operation of trucks, should carefully analyze what effect that operation is going to have upon the essential rail carried. The public cannot maintain two freight transportation agen-

cies without paying for both; and unless each performs a service which the other cannot do economically and efficiently, both should not be supported.

Railways are using trucks to assemble freight in cities in lieu of switch engines, and in some cases operate lines of trucks in lieu of local freight trains. Especially in large and congested terminals the use of trucks, whether by the railways or by others is economical because local freight trains, due to the light tonnage, station work and heavy switching cost incident thereto may be and often are unprofitable. Unlike the case of passenger traffic, freight train mileage may be reduced approximately in proportion when freight traffic declines.

Summary.—The situation may be summarized as follows: The superiority of the railway for long distance and bulk freight and passenger traffic is well established; motor truck and bus competition is not a factor in those fields. Commercial users of highways should be subjected to reasonable regulation and taxation. Existing and proposed State and Federal legislation, generally speaking, will provide for this. The extensive ownership of automobiles and the large mileage of improved highways have resulted in loss of most of the local passenger travel of the railways, except in the vicinity of the largest cities. The removal of local trains has left many communities with comparatively little railway passenger service. The small amount of local travel in many such instances does not warrant more railway service, but does warrant the operation of buses at comparatively frequent intervals. The station to station, and even shorter travel, which would not go by rail, makes up a considerable portion of the bus traffic. The bus business promises to increase if better service can be given and if the cost of operation can be reduced. The additional business which buses may expect will come largely from automobile users rather than from rail patrons. Buses may serve to supplement railway transportation more effectively in some localities, if managed by railways, than if operated independently. Street railway and interurban electric lines are making extensive use of buses. The field of the privately owned motor truck is wide, taking the place, as it does, of the horse-drawn vehicle both in the city and in the country. The common carrier truck has a much narrower field, because of the competition with the private truck on the one hand, and the common carrier railway on the other hand, the latter unquestionably being more economical for any but comparatively small lots and comparatively short haul. Motor trucks relieve railway terminal congestion by moving freight direct from door of consignor to door of consignee. In many cases, this does not represent a loss to the railway because at large centers, where trucks are most used, the terminal costs may absorb the profit of rail haul on local freight.

In considering public convenience and necessity—the sine qua non for any permit to operate a commercial vehicle on public streets or highways—due regard should be had for the existing modes and means of transport. When essential carriers are able to give service that is measurably similar to that proposed, or when the success or efficiency of the existing essential carrier would be seriously impaired without definite and distinct improvement in service to the public, then public necessity does not warrant the new facility, and it is in the true public interest to deny the application. The public must support whatever transportation agencies are maintained and should not undertake two where one will suffice. On the other hand, where such additional facility is in the public interest and, therefore, is permitted, it should not be hampered by undue restriction or unfair taxation, but should be encouraged to operate as efficiently and cheaply as possible. Under the accepted scheme of providing public transportation in this country, the service is rendered at cost; including in cost, however, a fair return upon the value of the property used for transportation purposes. So long as this principle obtains, and for practical purposes that is so long as transportation is furnished by private rather than by government agencies, it is in the true public interest to avoid unnecessary duplication of capital, and in every other reasonable way to help both old and new carriers keep down the cost of producing transportation. Cheap transportation of the highest quality is the key to much of our past and possibly more of our future prosperity.

Colorado Road School and Conference

A Road School and Conference will be held in Boulder, Colorado, in December, 1926, under the auspices of the University Extension Division and the College of Engineering of the University of Colorado, with the active co-operation of the United States Bureau of Public Roads, State Highway Department, State Association of County Commissioners, and Colorado Municipal League. The large number of organizations co-operating will assure an interesting and worth-while program. The purpose of the school will be to study all types of roads and road building from the standpoint of financing, testing of material, traffic control, construction and maintenance, and road improvements. Experts in each line will address the conference.

Safety Considerations in Highway Design

An Address Presented April 22 Before Annual Convention of the Western Society of Engineers

By SIDNEY J. WILLIAMS

Director Public Safety Division, National Safety Council, Chicago

In considering the safety features of highway design we must first ask what the highway is to be used for. I refer especially to the width and the speed of the vehicles. As for width, most highway engineers have come to believe that 18 feet should be the minimum and many advocate 20 ft. A 20 ft. roadway, however, is not safe for the newer type of busses, having a wide spread of the rear wheels, traveling at high speed (sometimes 50 or 60 miles per hour) and passing similar busses or other cars traveling in the opposite direction. For such traffic a 24 ft. roadway was advocated by the 1924 National Conference on Street and Highway Safety which added "whether this extra width should be provided at public expense to accommodate a relatively small number of vehicles operated for hire is an economic question outside of the province of this Committee." The report adds that if such vehicles operate on highways less than 24 ft. wide their speed must be severely restricted when passing other vehicles and that they should not be allowed to operate at all on less than 18 ft. highways.

Highways Built for Traffic.—While the economic question just referred to was naturally dodged by this conference, it cannot be dodged by our highway authorities who are here confronted with much the same sort of problem that has always confronted the designers of railroad bridges—namely, how much additional investment to make on account of probable future increases in sizes and weights. I do not pretend to answer this question other than by stating the belief that, after all, the highways are built for the traffic and not the traffic for the highways; with the present trend for more, larger and faster busses, we must prepare somehow to handle them with safety to themselves and to other vehicles on the highways, and this means a clearance of at least 2 ft. between the edge of the tire and the edge of the pavement and more than that clarance between passing vehicles. Bridges especially should be made wide enough to care for future as well as present demands, with 22 ft. of clear width as a minimum and more if possible and, on long bridges, separate sidewalks for pedestrians or, at least, occasional safety zones outside of the roadway.

2 and 3-Lane Highways.—Many two lane highways today are over crowded, raising the question of increasing the width to accommodate three, four or more lanes, or building additional parrallel highways. This is not particularly a safety question except as to the three lane highway. In common with most highway engineers I do not advocate the three lane highway except in very special cases. Aside from any other consideration it is evident that on a highway where lanes of traffic can move safely—say 27 or 30 ft. wide—four lanes can move unsafely, and frequently will. On a three lane highway, lines on the pavement delimiting the lanes are particularly necessary.

Pavement markings in general are being used more and more, and should be. I believe in the Illinois practice of center lines on straight-aways as well as on curves for I believe they add much to ease and safety in driving. In some of the eastern states, a contrary opinion is held, namely, that the center line should be used only on curves and in other places where the overtaking of another car is forbidden by law; that is, the motorist should know that he is never permitted to cross or drive on the wrong side of a center line. If this is to be the rule, then obviously center lines could not be used on straight-aways because then there could be no overtaking. This matter was argued at length in committee meetings of the National Conference, two years ago, leading to the compromise decision that a white line should be used only at points where it is illegal to cross the line or be on the wrong side of it; that black lines may be used elsewhere, as on straight-aways.

Pavement Markings.—In addition to center lines, other pavement markings are being and should be used more and more for both safety and convenience, to supplement signs by the roadside as a means of telling the driver what he is to expect or what he is to do. The National Safety Council has been making a study, not yet completed, of the extent and nature of the use of pavement markings both within

cities and outside. Eventually, and the sooner the better, there should be some standardization of the design and meaning of pavement markings, under proper auspices, and covering both city streets and rural highways, so that a certain marking will mean the same thing not only in different states but within cities as well as without. There is great need for engineering study and development of satisfactory permanent pavement markings inlaid or otherwise which will be cheaper in the long run than the frequent renewal of surface painting.

Vehicle Speeds.—For what speeds shall our highways be designed? With the developments in vehicle design and construction, highway speeds have been increasing and will doubtless continue to do so.

Some of you know that in the matter of automobile speeds within cities I have been among the persistent advocates of the enforcement of moderate speeds, for example, a prima facie limit of 20 miles per hour in residence districts. This is because, in cities, we have various conditions which cannot be altered nor certainly controlled,—buildings and other obstructions to view, congestion of traffic, and most important of all, the ever present likelihood of some unexpected or careless action on the part of other users of the highway, drivers and pedestrians and especially children. Furthermore, we know that to relieve congestion and expediate traffic in a large city, what we need is not a higher maximum speed but a more uniform and therefore a higher average speed through the elimination of obstacles and delays.

On the open highway the situation is different. There, higher speed is really a boon to the motorist traveling a considerable distance; and speeds of 40 or 50 miles an hour may be perfectly safe, with a good car, tires in good condition, no pedestrians, a well built highway, and no obstructions to the view. With further advances in the reliability of cars and tires these figures may be still further increased. I do not wish to be understood as advocating any change for the present, at least, in the primi facie limit of 35 miles per hour on the open highway which is found in the laws of many states and in the model motor vehicle law recently developed by a representative national committee and adopted by Secretary Hoovers National Conference on Street and Highway Safety. But it seems to me that the occasions on which the prima facie may be exceeded with entire propriety, both legal and moral, are much more frequent on the open highway than in the city and that even assuming complete compliance with existing laws, speeds for 40 and 50 miles per hour must be reckoned with by the highway builder. I must add that the model law already referred to recognizes the present trend by providing that where a highway is made an arterial or through highway with stop signs at every intersection, the 35 mile prima facie limit may be increased by action of the local or other regulatory authorities.

This paper is not intended to be a discussion of automobile legislation nor of safe speeds and I have mentioned these only by way of pointing out that modern highways must be designed on the expectation of rather high speeds even at present, and with the likelihood that these will increase rather than diminish in the future. This means, obviously, generous widening and proper super-elevation of curves, together with transition curves, as already generally accepted by designer. It also means that the removal of obstructions and the providing of a clear view is of ever increasing importance.

Distance for Unobstructed View.—The distance along which an unobstructed view is necessary, depends directly on the stopping distance of, not the best nor even the average but the most poorly braked cars. Recent studies of the U. S. Bureau of Standards and others have shown that we cannot hope to enforce a higher standard for brakes than that corresponding to a stopping distance of 50 ft. from a speed of 20 miles per hour. A very large percentage of cars now on the highway, including a great many trucks, do not conform to even this standard. For a speed of 40 miles this means a stopping distance of 200 ft.; a speed of 60 miles means a stopping distance of 450 ft. Perhaps the latter may be disregarded because a car capable of a 60-mile speed, with any sort of comfort to the occupants, is ordinarily a car equipped with good four-wheel brakes. But there are, and will be many flivvers on our highways doing 40 miles an hour, that would have a hard job to stop from that speed in 200 ft. Adding a like distance for the on-coming car and we see that an unobstructed view of 400 ft., at least, is necessary for safety, or 200 ft. each way from an intersection. These distances should really be increased in view of the likelihood of skidding and also to allow for the interval which elapses between the sight of the oncoming car and the actual application of the brake. Looking ahead five or ten years it is easy to forsee a time when a point of obstructed vision on a highway will either be the scene of numerous wrecks or will force such a slowing down as to constitute a serious "bottleneck." We shall have to spend more money, in the future, in the removal of obstructions, even trees and shrubbery of artistic value as well as sign boards of inartistic value; the widening of cuts at curves and at intersections; the increasing

of vertical radii at crests; and even the condemnation of buildings and other structures where they constitute a serious obstruction to view.

I have omitted to mention various other safety considerations because they are either obvious or have been already accepted by up-to-date designers; items such as minimum crown; easy grades especially when combined with curves; liberal curve radii; and the provision and maintenance of adequate shoulders. Highways signs are very important for safety but this forms a subject in itself. The same may be said of the elimination of railroad-highway grade crossings, and their protection, and designers have likewise become alert to the need for special provisions at the intersections of two important highways. We have come to recognize that the parking of vehicles on the highway is dangerous as well as a nuisance to other motorists and that this can be prohibited only if we provide parking places not more than 300 ft. apart, outside of the pavement line, or better still, a continuous shoulder wide enough for the same purpose. We also recognize today the importance of proper selection and conditioning of detours, for both safety and comfort. The initiative of the manufacturers of new types of metal guard rails has brought rapid progress in this field, —for while the slow processes of safety education are striving to make railings unnecessary, the highway designer, facing a condition and not a theory, must still share the responsibility commonly attributed to Providence for watching over drunken men and other fools.

Super-Highway Never Reality.—The super-highway—that dream of the highway engineer, in which capacity, safety and speed shall all be at a maximum—is coming every year a little closer to reality. The ideal, of course, is a roadway or set of roadways of ample width, proper surface, and each of them carrying homogeneous traffic in one direction only, with no pedestrians and no grade crossings of any sort. In a few highly congested districts it will be economically possible to build such arteries of transportation.

But ninety-nine and a fraction per cent of our highways will always be in the other class requiring a continual balancing of safety versus speed versus cost. Here the "safety man" asks nothing more than that the highway designer accept safety as one of the objects—not the sole object—of his design, and I for one have nothing but praise for what the highway engineers of today are doing to make our highways safer, with the limited funds at their disposal. The real safety problem on our highways is not poor design but incompetent and careless driving.

Trying to Measure Riding Comfort

Complete solution of the riding qualities complex is brought nearer by the development of several new instruments that make possible the rapid, accurate and convenient measurement of vibrations that occur when a motor vehicle is driven over the road. Illustrations and descriptions of the new instruments and some of the results obtained were given by R. W. Brown, of the engineering laboratories of the Firestone Tire & Rubber Co., at the summer meeting of the Society of Automotive Engineers at French Lick Springs the first week in June.

When a wheel fitted with a solid tire strikes a rectangular obstruction one inch high and 3½ in. wide at a speed of only nine miles an hour, the greatest upward thrust of the axle lasts only about one-thousandth of a second, and when it strikes the ground the downward thrust of the axle lasts only 7/10,000 of a second.

Experiments showed that action of such short duration can be measured satisfactorily by the use of an electrical contact and a spring-actuated escapement, such as that of a stop watch with the balance wheel removed. For recording the movements, a series of three drums driven by a precision constant-speed electric motor gives recording paper speeds of 0.1 in., 1 in. and 30 in. per second, and a series of fourteen magnets operates styluses that are constantly in contact with the paper. Other recording elements give records of speed, time and other factors that it is desired to correlate with the vibration record.

Tests made show that a pneumatic tire passing over a 2-in. obstruction caused an upward thrust of 1¼ in. at a speed of 9 miles an hour and only 1 in. at 17 miles an hour, whereas a cushion tire caused a thrust of 1⅝ in. at 9 miles and 1⅞ in. at 17 miles. Thus, the higher the speed with the pneumatic tire the less was the vertical deflection, while with the cushion tire the deflection increased regularly as the speed was increased. A 33 by 5 in. high pressure pneumatic tire gave almost twice as much axle displacement at 15 miles an hour as a 34 by 7.30 balloon tire, but at 35 miles an hour there was almost no difference.

Highway Cops Carry First Aid Kits.—Dodge County, Wisconsin, has furnished its patrolmen with first aid kits to be used in case of accidents on the highways. The equipment, which consists of bandages, medicines, etc., is contained in a compact metal case which is carried in a saddle-bag at the side of the motor-cycle.

Modified Earth Roads

Method of Applying Thin Layers of Sand or Gravel Described in Paper Presented at Southwest Road School and Show

By W. A. STACEY
County Engineer, Hutchinson, Kansas

The development of any state road system, or for that matter, any county system, is gradual. From a strictly economical standpoint, what you spend on a road should be governed by the traffic on it or the traffic you expect to be on it immediately that it is improved. In most cases however, funds are limited and mileages are large, consequently the quality of the road must often lag behind the demands that the traffic is making of it.

The foregoing pictures represent stages in the construction of earth roads; which type of road we will always have and it will comprise the largest fraction of the total road mileage.

The grading and draining of the road is, of course, to be followed by the establishment of a patrol system of maintenance. Thereafter you may note that a minor portion of your road is very difficult to maintain and is the cause of nearly all of your traffic troubles. Assuming that by reason of light traffic or lack of funds, paving is not contemplated in the near future of this road, then the next step in development should be the modification of the earth surface by some material that will allow the road to be maintained properly and give service to the traffic.

Materials Used as Modifiers.—The modifiers usually are: For clay roads, sand or gravel; for sand roads, sand-clay or clay-gravel. Given proper drainage and the proper modification of the top surface, the earth road is enabled to carry satisfactorily a much heavier traffic than was previously possible.

This modification of the earth surface to bring about the sanded wearing surface may be produced by construction alone or may be produced hand in hand with the regular maintenance of the road. By the later method I mean the application of thin layers of sand or gravel on the clay surface and working it into that surface with the assistance of the traffic.

The development by either method of the sanded surface is, I believe, a common and standard practice in almost every place where there is material to produce it with. Our neighboring states of Colorado and Nebraska, have many miles of it. Likewise, many states in the south are relying on some form of it for the improvement of parts of their state systems.

Some counties in Kansas have a considerable mileage of some type of the sand and gravel surface: Allen, Anderson, Cherokee, Labette, Montgomery and Wilson having let Federal Aid contracts for such work as early as 1919-20, followed more recently by some of the more western counties.

Method of Constructing Sanded Surface.—I will outline our experience in Reno County with the production of the sanded surface on earth roads. Beginning about 10 years ago, fairly steady progress has since been made in increasing the mileage of this surface on the county system. For the reason that all our share of the Federal Aid money has been put on paving and bridges, this light surfacing has been done as county or state aid projects.

Old Road Just Newly Resurfaced

The material to produce this surface is obtained locally from two sources:

1. Pit run sand testing 5-20 per cent on a ¼ in. screen is found in the bed and valley of the Arkansas River and several creeks in the north half of the county.
2. Outcrops of sand with a clay binder are found in the hills of Permian formation in the south half of the county.

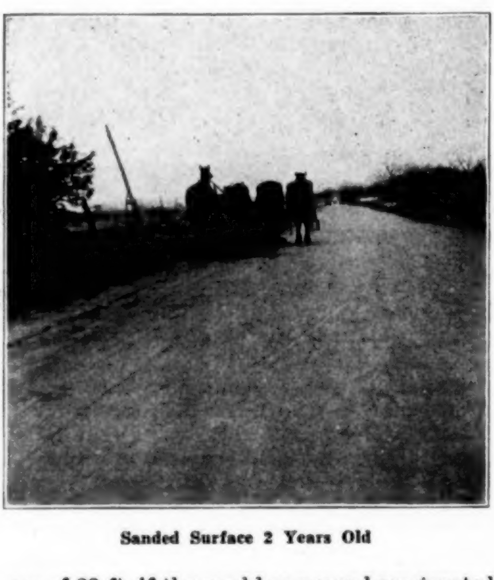
The binder varies from 3-20 per cent and the sand alone tests about 10-15 per cent on a ¼-in. screen.

As you may infer, in the latter case it is simply a strip and load proposition; whereas in the former case it is usually necessary to pump the sand out in a stock pile and allow it to dry out before it can be used. A 6-in. sand pump and a tractor are used to get the sand out and the cost of production is ordinarily 35-40 ct. per cubic yard. Sometimes we own the pit and sometimes we pay the owner a royalty of 10 ct. per cubic yard removed.

Disregarding some 10 or 12 miles of county road where natural sand-clay is taken from the ditches by heavy blade grading, the surfacing work in this county is divided as follows:

1. Treatment of clay roads,
2. Treatment of sand roads.

The sand put on clay roads is ordinarily clean or contains very little binder. We expect the road to furnish the binder. The usual practice is that the road is graded or has been graded to a uniform width and crown on an established center line. The surface of the road should be firm and smooth before surfacing is applied. The sand is placed at the rate of 400-450 cu. yds. per mile on a roadway of 28 ft. if the road has never been treated before, and 300-350 cu. yds. per mile if it has been sanded before. As soon as dumped on the road, the sand is spread by the patrolman with his grader over the surface. When so spread, there is not much inconvenience to the traffic and after the second rain, if the patrolman has been diligent, the bulk of the sand has worked into the crust of the road, leaving usually just enough on top to cushion the surface and make maintenance easy. If the grade and drainage of the road were good when the sand went on, and the patrolman is careful to prevent loss of material into the side ditches, we ordinarily do not find it necessary to renew the surfacing for 2 or 3 years. This is especially true if care is taken during ditch cleaning with a tractor to avoid spreading an excess of soil on the roadway. It is often stated that the best way to sand a road is to windrow the material on each shoulder and then work it gradually into the surface under traffic. Ordinarily it is very successful, but we find two little objections to this method, namely; that in case of rain the ridges of sand hold water on the road, and in case of a snow blockade they are generally pushed into the ditch by the snowplows.



Sanded Surface 2 Years Old

Sanded Surface 5 Months Old Carrying 800 Vehicles Per Day

Sand-Clay Construction.—Although we have built a few miles of sand-clay on clay according to the usual rules for construction; that is by a heavy application of sand together with scarifying, discing and mixing, nearly all the treatment of our clay roads has been by the light surfacing process. We have preferred to put on less and put it on oftener for the reasons of less initial cost and less inconvenience to traffic while the surface is being formed.

Roads in the sandhills or on such sandy loam as to contain no binder worth mentioning are more difficult to give a satisfactory surface. We have used two methods:

1. Put on clay 6-8 in. thick to furnish the binder and then spread the coarse sand on it in the usual manner, or

2. Put on 6-8 in. of a natural sand-clay mixture from some pit.

Naturally which method is used depends entirely on what materials are available. The blowsand at the side of the new road bed is worthless except to shoulder up with on a very flat slope.

This work is generally done in the fall and winter under favorable conditions of soil and labor supply. We have been fortunate in that it has been rarely necessary to haul material more than 6 miles. Favored by such conditions, the cost of placing or renewing a sand surface on a clay road usually does not exceed $600 per mile and the original sand and clay roadbead for a sandhill road not over $1,500-2,000.

In the selection of material we note one point. We do not like to use a fine grained sand or one testing less than 10 per cent on the ¼ in. screen. Such material does not work into the surface satisfactorily and tends to produce waves of chatter bumps under traffic. Screening of sand to proper grading can easily be done, if you are getting it from a pump; by putting a flat screen in the bottom of the discharge trough.

Reno County has 62 miles of pavement on its 370 miles of county and state road. We expect to build more pavement but at the same time we intend to continue sand surfacing on the rest.

Considering the fact that practically every county in the state has available some kind of local materials—it may be sand, gravel, chats or limestone screenings—I believe it is worth while to bear in mind the possibilities of improving existing earth surfaces with them on those roads that it is not possible or not necessary to otherwise improve in the near future.

Concrete Pavement Construction at Beloit, Wis.

An exceptionally efficient construction organization was employed last year in paving the business streets of Beloit, Wis. Some interesting details of the work are given by G. E. Heebink, City Engineer, in a recent issue of the Concrete Highway Magazine.

A one-course 8-in. concrete pavement with 42 lb. of steel mesh per 100 sq. ft. was specified for heavy traffic. Separate combined curb and gutter was designed for these streets, showing a sloped curb, 6 in. high and 6 in. wide at the top with a steel curb guard along the exposed edge. The gutter slab is 2 ft. wide and 8 in. thick, reinforced with three ¼-in. longitudinal steel bars. One-inch premoulded bituminous expansion joints were placed at 25-foot intervals. A 1:1¾:3½ mix gave a dense concrete with a good surface finish. Standard corner radius is 20 ft. One-inch premoulded expansion joints were placed between sidewalk and curb and between gutter and pavement slab. Car track was handled as a separate slab, 7 ft. wide and 12 in. deep, of 1:2:4 concrete, monolithic around the rails and steel ties. Four ½-in. twisted steel rods were used for longitudinal reinforcement.

The pavement slab proper, of 1:2:4 concrete, extends from the track slab to the gutter. Broad Street without car track, paved 73 ft. wide, was laid in three strips, the center first; ⅜-in. transverse expansion joints were placed 40 ft. apart. The surface was struck off, rolled three times with a metal roller of not over 50 lb. weight, and belted twice with a 6-in. belt. The water content was limited by a slump of not over 4 in. for hand finished pavement. Surface irregularities greater than ¼-in. in 10 feet were immediately corrected.

The contractor's organization was exceptionally efficient. Storage piles and portable bins with measuring hoppers were maintained at street intersections about three blocks from the work. Sand and gravel were delivered by truck and loaded into the bins by a clam shell bucket. Cement storage was adjacent. One-ton Ford dump trucks delivered one batch each into the skip of the 5-bag Koehring mixer on the street. The contractor's force was made up as follows, after rough grading and curb and gutter were completed:

DELIVERING MATERIALS

1 clamshell operator.
1 man at charging bins.
2 men at cement storage.
9 trucks and drivers (8-10 one-ton Fords.)

FINE GRADE AND FORMS

2 form setters.
2 men, team and Fresno fine grading.
1 man handling expansion joint.

PLACING AND FINISHING

1 foreman.
1 mixer operator.
1 man charging skip of mixer.
5 men shoveling concrete and placing reinforcement.
2 men handling strike off.
1 finisher floating behind strike off.
2 finishers, edging, rolling and belting.
1 finisher checking surface with 10-foot straight edge.

This organization completed over 78,000 sq. yds. of pavement averaging 7 in. thick and including 3,845 sq. yd. of car track 12 in. thick in 61 working days, an average of 1,300 sq. yd. per 10-hr. day. 2,027.5 lin. ft. of car track paving, an average of 7 ft. wide and 12 in. thick with steel ties, were placed in 3 days. 7,816.4 sq. yd. of 8-in. pavement slab were completed in 4 days and 4 half days, an average of 1,302.7 sq. yd. a day, with surprisingly little hindrance to store business and sidewalk traffic. George Welch, Beloit, Wis., was the contractor.

Economic Considerations in Highway Location

Factors Which Should Form Basis for Highway Project Outlined in Paper Presented at Southwest Road Show and School

By A. R. LOSH
Engineer, U. S. Bureau of Public Roads

In addressing the American Road Builders' Association,* Col. W. W. Crosby, Location Engineer of the Pennsylvania Department of Highways, stated that the selective location of highways has been mainly political, that road building has overshadowed highway engineering, and that mass production of roadway surfacings tends to interfere with the proper study of location problems.

However reluctant we may be about admitting it, nevertheless we recognize the fact that Col. Crosby is in the main stating the facts in the case. For the administrative authority to actually determine upon a location without or contrary to the advice of its engineering organization is no uncommon occurrence.

Considerations Affecting Locations.—While the reason for such action in many cases is as Col. Crosby states "political" I would not want to give the impression that this is true in all cases. From my observations I believe there are also the following conditions which contribute to this lack of engineering consideration.

First: Many highway officials and influential citizens continue to look upon all highways as local institutions. Recently I discussed a proposed interstate highway with the manager of a chamber of commerce representing a city of 200,000 population. This highway will, when built, carry from 8,000 to 10,000 vehicles per day, about 90 per cent. of it being through traffic. Yet the chamber of commerce official wanted the road so located as to be from 3 to 5 miles longer in order to provide a "butter and egg" road to his city. He could not see but that it was entirely proper and economical to add from 25,000 to 50,000 vehicle miles per day to the through traffic in order to provide a small local service which could be taken care of equally as well by means of a lateral road leading into the main highway.

Second: Failure on the part of the engineer to consider as a comparable weight the value of the local traffic. That is, there has been a tendency for the engineer to connect the two objectives by the shortest route without regard to the potential traffic on various routes between these points.

Third: Also, failure of the engineer to have developed logical and well grounded reasons for his location other than "the shortest distance" or "the least cost" and also failure to provide highway service for the local institutions. To overcome this condition it will be necessary for the engineer to "sell" his location ideas to his administrative board. The engineer must consider highway service rather than an individual road project and approach the problem from the angle of economics rather than just "road building."

The purpose of this article will be to point out some of the economic considerations which

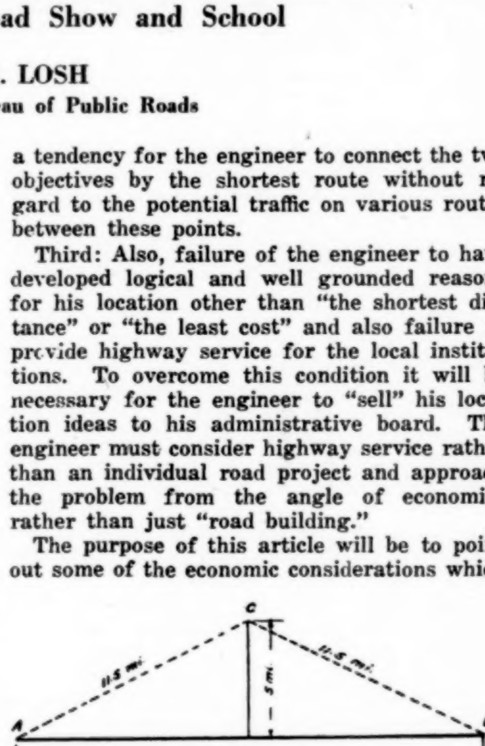


Fig. 1

should form the basis for a highway enterprise or project. It is clearly recognized that there are important factors other than the purely economic ones to consider in the location and design of public highways, but these are usually more readily discernible and seldom fail to receive due consideration. To the engineer is left or assigned the task of developing the economic side of the argument if it is presented at all.

Within the limits of this article the writer cannot hope to do more than outline the major points of the subject and give a brief discussion of the same.

Frequently a project may be determined by some administrative body or legislative act and the work of the engineer is restricted to the established limitations. In such cases his work will be entirely the sphere of the detail location and design.

*See Roads and Streets, March 3, 1926.

The Preliminary Study.—Public necessity and convenience initiate highway projects and determine their general route. The public travels to and from regions and centers of importance and general interest. The line of travel is the line of least resistance. The route may be indirect and circuitous but it will offer the least obstruction to the movement of traffic. As the route becomes better established it develops more traffic and eventually the demand arises for betterment and improvements. Unfortunately our travel has been principally from point to point or from one city to another and as a result we have taken up highway building on that plan. State and national legislation of the past decade has recognized the necessity of a system of highways serving the country as a whole and has provided the necessary legislation and

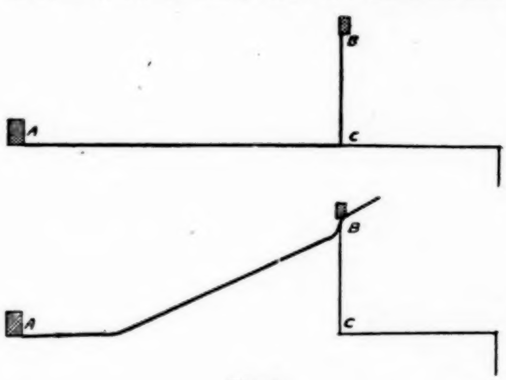


Fig. 2

administrative means for securing it. A highway commission now has the task of providing highways for state and interstate traffic and can view their work on that basis. An individual project now becomes a small section of a main highway and while the town to town feature is still the important traffic, the more extensive use of the highway is not overlooked.

When the engineer is called upon for a report and recommendation on a proposed project, he should first ascertain what part the project will have in the general highway system. Consideration should be given to its use, both as a state and as a local road and each such use given due weight. The local interests are always on hand to urge their viewpoint while the engineer must ordinarily present the arguments for the through highway interests. Influential citizens and public officials will take up the case from the local viewpoint but the wider traffic interests of the state are not represented.

Determination of Control Point.—The proposed project will ordinarily have termini tentatively at least determined. If these are not suitable for control points on the through highway the engineer should establish other termini which will properly fit into the larger highway plan. Ordinarily these will be important towns or cities.

A town or city will be a control point for one or more of the following reasons:

(a) Its geographical location such that it is on or near the route between the adjacent control points.

(b) A terminal for highway traffic of sufficient importance to make it a control point.

(c) And closely related to (b), provide a junction with other important highways.

The first condition is obvious.

The second condition requires some discussion. It is based on the theory that a road into or near the city is the most economical one due to the amount of traffic which would normally go to and from the city even if there were a more direct road between adjacent control points.

This—Consider A and C as established control points on the main highway while B is located between A and C, but not upon the direct line from one to the other. There may be sufficient traffic between points A and B and between points B and C to justify the line ABC whereas there would not be a justification for a line from A to C with a branch line to B. Under such conditions B would be a control point on the main highway.

The third condition is similar to the second. It has to do with distributing traffic to several highways at a common junction point instead of a traffic terminal point. The importance of this connection is frequently overlooked especially in those cases where the "checker board" system of roads prevails. Here there is a tendency to follow section lines with even main highways and intersections at points of no importance to the public and little or no local developments result thereby.

There are occasionally topographic conditions which must be considered in establishing these major control points but as a rule topography affects only the detail location between major control points.

Fixing Route Between Major Points.—After determining these major points for the highway the next step is to fix upon the route between these points. Here the engineer will need consider the relative weight of "through traffic" and "local traffic" so that he may base his location on economic deductions. He should not blindly pick out the shortest distance between the established control points unless it is the economic line for the highway.

The economic selection would be the line which would give "The long run least cost for

unit of service, including therein construction, maintenance and traffic operation." The shortest line in itself might be also the cheapest in both construction and maintenance but if it requires numerous costly lateral roads to bring the traffic into it or if it would result in a large portion of the traffic using another road, it can readily be seen that the cost per unit of traffic might be higher than some other line.

There are factors other than distance which affect the cost of transportation on the highways, such as—

(a) Grades.
(b) Surface condition of road.
(c) Alignment where same affects speed and consequently time.
(d) Conditions contributing to accidents.
(e) Conditions causing frequent stopping and starting, loss of momentum of machine through use of brakes; extra wear and tear on tires and machines.
(f) The available tonnage to transport.

There are also some other considerations which should receive the attention of the engineer. In the first place, there is no competition between highways. The public uses them all and pays for their upkeep through some form of taxation. The public is interested in highway service and not in individual road projects. Therefore, the engineer should approach his problem for the viewpoint of the highway system as a whole rather than that of a road from A to B.

Railroads have found it profitable to build their lines where there is something to transport. Highways are not dissimilar with respect to economic principles. Railroads build near enough to towns and cities to secure their business and in the building of roads the engineer must not overlook the opportunity to add tonnage to his line.

Local Traffic Consideration.—In selecting the general route to be followed between the control points, this question of local traffic cannot be ignored, except in those few cases where the through traffic is of such a density as to make the local traffic insignificant in comparison. Frequently it will be found that there are several routes which are, to all practical purposes, equally desirable for the traffic from one control point to the other. Obviously under such conditions the route which would offer the greatest advantages to local traffic would be the preferable one.

In studying the problem the engineer will find himself between the two extremes of either greatly lengthening the line to give more local service and restricting it to the minimum length and practically disregarding local traffic.

One line of reasoning is to build the roads at present for local needs with some form of connections to take care of through traffic and later build a system of through highways on more direct lines.

We believe this to be an unsound policy for the following reasons:

(a) If the longer line is adopted and used a number of years, there will be developments which would be seriously impaired by a radical change in location. It is apparent how property values might decrease under such conditions.

(b) Changes in location in the future will probably be more expensive than at present

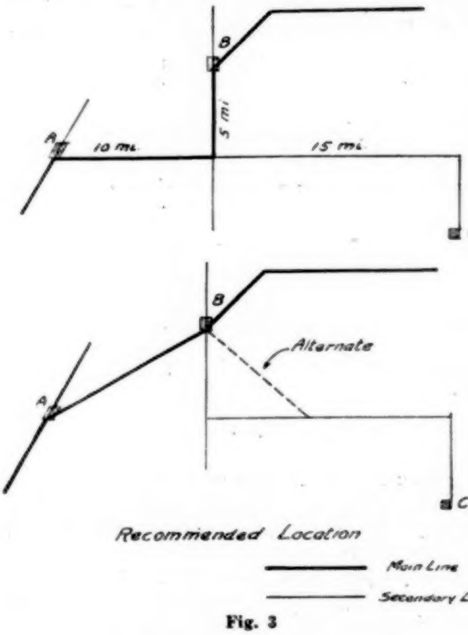


Fig. 3

due to increased cost of right of way and heavier damages.

(c) The structural value of a well maintained road bed increases and after a number of years use becomes well compacted so that no further settlement occurs. It is then well suited for further improvement. This would be lost where new location has to be secured.

(d) The real structural needs of the main roads are more expensive than those of the local roads; therefore, if the main road mileage is held to the minimum, it will be possible to construct more miles of local roads as the saving of one mile of main road will ordinarily be sufficient to build from two to four miles of road suitable for local needs.

Obviously all local service cannot be pro-

vided directly by the main line highway. If one section of the community obtains direct service, another section cannot.

The economic plan is for the engineer to secure the ultimate location for the through line at the first stage and provide for local development with short lateral roads leading into the main highway. This will also permit future development with the minimum amount of local friction. To do this it is essential to develop a general plan for the highways of the entire community contiguous to the through line.

Financing and Highway Location.—Unfortunately on many highway projects the method of financing has controlled the location of the highway. Road district and county bond is-

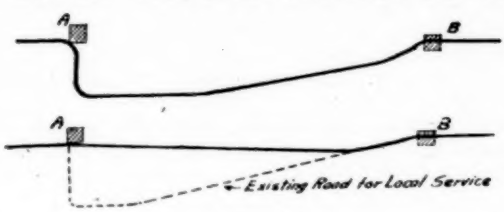


Fig. 4

sues with a highway program arranged to secure the needed number of votes has been responsible for much faulty location in the past. Under such conditions the engineer had little opportunity to develop a location along economic lines. Financing is dependent upon legislation and administration and should be definitely arranged for a given project after its location is determined. With a major portion of highway funds now being derived from auto fees, gasoline and general taxes, the highway administrator should feel free to adopt a broader policy on highway financing. He need not be led aside by the argument that "so and so" is the big taxpayer and consequently the highway should be located a certain way. The road user is now the big taxpayer and his interest will best be served by obtaining for him the greatest possible amount of road service for the taxes he pays.

One of the most common problems the engineer faces is whether or not to depart from a direct location in order to give highway service to a small city or town or to a certain community. We have previously suggested the solution by looking upon the road needs of the community as a whole.

Analysis of Two Proposed Roads.—To illustrate this case (Fig. 1) let us assume a proposed road between two towns A and B, 20 miles apart by the most direct route. It is also desired to give road service to a third town "C" situated 5 miles from the direct line between A and B. Assume also a possible route through the towns A, B, C, 23 miles long. Then the problem is whether to build through towns A, B, C, 23 miles of standard state highway or build 20 miles of standard state highway for "A to B" and five miles of secondary road from this line to "C". Let us assume daily 1,000 vehicles from A to B; also 200 vehicles from C for each A and B. Then the traffic in vehicle miles is as follows:

First Route (A to B Direct)

Traffic A to B 1000 vehicles x20=	20,000 vehicle miles
Traffic A to C—200 vehicles x10/5=	3,000 vehicle miles
Traffic B to C—200 vehicles x10/5=	3,000 vehicle miles
	26,000 vehicle miles

Second Route (A to C to B)

Traffic A to B—1000 x23=	23,000 vehicle miles
Traffic A to C—200x11.5=	2,300 vehicle miles
Traffic B to C—200x11.5=	2,300 vehicle miles
	27,600 vehicle miles

Assume main line construction costs $25,000 per mile maintenance $500 per mile per year. Assume a secondary line construction to cost $8,000 per mile and maintenance $150 per mile per year. Assume interest on construction of 5 per cent. per annum. We have the following:

First Route—

Cost of construction A to B—$500,000.	
Interest	25,000
Annual cost maintainence 20x500	10,000
Construction cost of lateral line—40,000.	
Interest	2,000
Annual maintenance	1,200
26,000 vehicle miles @.10	2,600
Annual cost	40,800

Second Route—

Cost of constructing line ABC—23 miles 575,000.	
Interest	28,750
Maintenance	11,500
27,600 vehicle miles @.10	2,760
	43,010

This rather simple method of analysis gives a comparison of the two proposed lines.

Another and not dissimilar location problem is that of combining roads for some distance from the city. Fig. 2 is a usual case of this kind. By using the section line combination as desired by the local people there is an increased traffic mileage of 15 per cent. and construction costs will also be higher due to a greater mileage of high class construction required.

Fig. 3 represents a case of location and traffic distribution at intersections. This is an unusual case but the importance of the main line from a traffic standpoint fully justifies the recommended arrangement.

Fig. 4 represents one of those "existing locations" which the local officials will insist upon following when the improvements are made. In this particular case a saving in dis-

tance of 20 per cent. could be effected by the recommended location and in addition thereto a reduction in curvature.

An Actual Location Problem.—An actual location problem as originally submitted to a state highway department and the location developed is shown in Fig. 5. The adopted location did not give direct service to as many farms as the one originally proposed but it does provide local service with only a small amount of lateral road construction. The saving on the main highway in construction cost alone is sufficient to build enough lateral roads to provide more local service than could have been possible under the original plan.

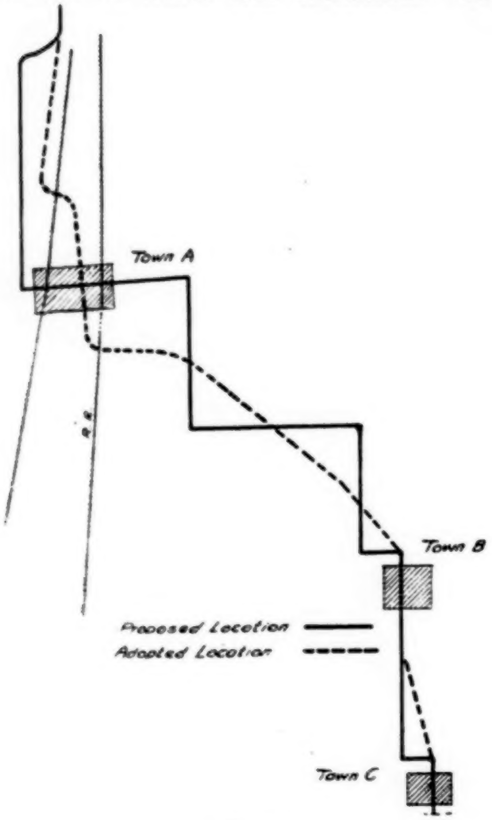


Fig. 5

Working Out Detail Location.—In working out the detail location the engineer can effect economics in the general located line, by taking advantage of topographic conditions, soils, available local materials or railroad facilities for imported materials. Reduction in grade and curvature will materially reduce the cost of road use and in some cases construction costs. Particular attention should be given to curves. Fig. 6 shows the saving in distance by the various curves, but there are other factors than distance to consider. Curve No. 1 with a 30 ft. radius or the right angle intersection would require a paved width of 40 ft. for a distance of 300 ft. each side of the intersection. Considering a standard of 18 ft. pavement curve No. 1 would require 5,436 sq. yds. between points A and B. In addition to this the safe speed limit would be about 12 miles per hour.

By adopting curve No. 2 with a 200 ft. radius the length of line is 1,914 ft., a saving of 86 ft., an extra width of 6 ft. would be required on the curve. This alignment would require approximately 4,038 sq. yds. between points A and B. The safe speed limit would be about 25 miles per hour.

The 500 ft. radius curve No. 3 would reduce the length of line by 215 ft. Allowing 2 ft. extra width on the curve the amount of pavement between points A and B would be 3,657 sq. yds. The same would be safe for speeds of 35 to 40 miles per hour.

A curve of 1000 ft. would not require extra widening or superelevation, would reduce the length of line 429 ft. and it would require only 3,141 sq. yds. of pavement and be practically as safe as a tangent for speed limits. Considering pavement at $2.50 per sq. yd., the saving over the right angle intersection is as follows:

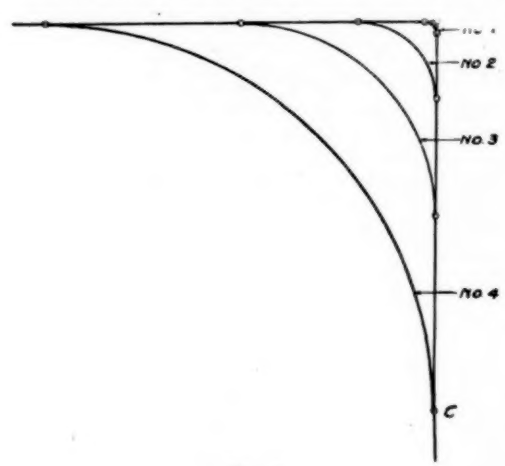


Fig. 6

200 ft. radius curve saves	1398 sq. yds.	or	$3,245
500 ft. radius curve saves	1779 sq. yds.	or	4,450
1000 ft. radius curve saves	2295 sq. yds.	or	5,840

Saving in operation costs would be in addition to the above, and the elimination of dangerous curves would be worth more to the public than the saving of construction costs. What curvature means in operation costs is a subject worthy of careful study and experi-

mental work. The wear of brakes, tires, and strain on the entire machine are the mechanical features which can perhaps be determined by experimental data. The loss of time due to retarded speed can be approximately determined. We have roughly estimated the sharp curves of about 50 ft. radius such as are found on the older roads, built for horse traffic, to be equivalent in point of time to ¼ mile additional travel distance. This subject—the effect of curvature—is one upon which much experimental work need be done and the highway engineer will welcome the contribution of such data.

More information on traffic conditions particularly its distribution between main line roads and local roads, would be beneficial.

To the engineer is the task assigned of looking to the future and working out our road problems so that present expenditure will not be misplaced. We would urge that the engineer endeavor to have his work lead rather than follow the developments of the country.

To do this we must anticipate the future needs for highways certainly insofar as the location is concerned.

The engineer should consider not a road project by itself, but as a part of the highway system of the country. He should realize that his location is made for the public and not for a section of the state or the county.

Concrete Overflow Pavement

Four years ago a section of concrete overflow pavement was built on a short stretch of road on Route 3 in the bottoms of the Great Pee Dee River at Mars Bluff Crossing between Florence and Marion, S. C. Though repeated floods have swept over the highway, traffic has never been stopped for a moment for any cause whatever and the 4,000 feet of concrete road, built on an unseasoned fill, have come through without a crack except one on the ramp at one of the small bridges where the fill was inaccessible for rolling.

An interesting description of this pavement is given in a recent issue of the Concrete Highway Magazine by J. M. Johnson, of Johnson & Roberts, Civil Engineers, Marion, S. C.

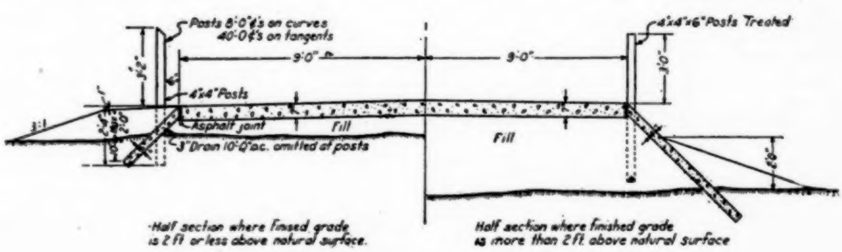
The concrete roadway is 18 ft. wide, 7 in. thick on a crowned filled subgrade. The sides of the fill, which ranges in height from 6 in. to 5 ft. are covered with 4-in. concrete aprons, joining the roadway slab at the outer edge on a 45-degree angle and extending 18 in. below the surface of the ground at the toe of the fill. Expansion joints were placed at 50-ft. intervals. The joints are slightly diagonal to the axis of the road. A 1:2:4 mixture was used.

The aprons had no joints, but were built as nearly monolithic with the roadway as possible. Post holes were left in the apron at 8-ft. intervals in which were placed 4 by 4-in. creosoted posts.

Within a week after the completion of the road and aprons, the highest freshet of several years came down the river. The results were watched with interest.

It was discovered that soon after the water started over the toe of the apron, the fill was undermined and about 250 ft. of the apron was moved. This was the only failure in the entire structure. Wherever the fill was washed away, earth was hand rammed under the slab and the fill brought back to its original contour. Alternate posts were removed and the post holes were thoroughly filled and rammed. The area around each post was then filled with rammed concrete. The hand rail was discarded as it was found to collect drift and obstruct the flow during high water.

Several freshets passed over the road without harming it after these alterations were made. In only one instance was there a slight movement of the apron. The movement was so slight that it required no replacement. But it showed that where the expansion joints, post holes and joints between apron and slab were watertight, no movement occurred. So the joint between apron and slab was chiseled out to ½ in. wherever the fill was 2 ft. or more in height and the space poured with hot asphalt.



Cross-Section of Overflow Road

Methods of Repairing Concrete Roads

Procedure of Indiana State Highway Department Described in Paper Presented at Annual Conference of Mississippi Valley State Highway Departments

By A. H. HINKLE

Superintendent of Maintenance, Indiana State Highway Commission

Many of the early constructed concrete roads were not properly constructed to carry the modern traffic and as a result they are requiring extensive repairs. Due to various causes the most extensive of which are defective foundations, overloading the pavement, and defects of construction which are liable to creep in, this type of pavement will, like any other type, need repairs. Also, it must be ever kept in mind that any type of pavement will eventually wear out. Because of this above and the great mileage of concrete pavement now being built, it is important that we study the most economical methods of repairing it.

The defects which are found in a concrete road may be classified according to the nature of repairs required, as follows:

1. Ordinary cracks and joints.
2. Large cracks and joints, say wider than 1 in.
3. Small depressions or disintegrated places in the surface shallower than ¾ in.
4. Surface depressions deeper than ¾ in. but with good concrete remaining that will serve as a base for the patch.
5. Portions of the slab which are broken through and which should be replaced with a full thickness of new concrete.

The various methods of repairing these defects are described in what follows:

Ordinary Cracks and Joints. — Ordinary cracks and joints should be filled with bituminous material, once a year being sufficient if on light traveled roads and two or more times a year if the traffic is heavy. In other words, the frequency of filling the cracks or joints should vary with the amount of traffic and hence the rate at which the filling is removed or the cracks develops.

Cleaning Joints or Cracks.—The crack should be well cleaned for a depth of not less than 3 in. of all dirt, dust or other foreign material. Under the heavy inflated tire traffic now going over most of our roads, the traffic itself largely does this cleaning due to the suction caused by the tire quickly rising from the surface. It is not deemed necessary to remove the particles of aggregate from the crack if they are not mixed with soil or other foreign material. The necessary cleaning can usually be done with an ordinary house broom. Compressed air outfits mounted on a truck by means of which compressed air under 75 lbs. to 125 lbs. pressure is forced through a nozzle, are very effective and will readily clean the joints or cracks to their full depth. Such a pressure is very effective in removing all loose spalls. When first filled, the crack is usually found open its full depth. For successive fillings the sweeping method apparently is satisfactory.

Grade of Bituminous Material.—Wo have been using an emulsified asphalt meeting our AE-1 specification; or a tar meeting our TP-2 specification which is practically the same as the TP-2 specification of the Bureau of Public Roads. Emulsified asphalt is applied cold and this is an item of economy which is quite a saving in cost, particularly where only small quantities of the material are required. The Tar TP 2 must be heated to a temperature of about 25° F. While the cost is less to apply the Emulsified asphalt, its first cost is considerable greater. The Emulsified asphalt freezes and is ruined in cold weather and hence it can not be satisfactorily used during the late fall, winter and early spring season. We have followed the policy of using the tar where large quantities of material were required. The cost of heating in large quantities is not so great as where a small quantity is required. Also, as it is usually desirable to do some work late in the season and early spring or even occasionally during the winter, hot tar is used at these seasons of the year .The Emulsified asphalt has an advantage in that it can be used when the surface is damp or even wet while for best results the tar should be used only on a dry surface. It will thus be seen that each of these two materials has its advantages under certain conditions of weather, quantity to be used, etc.

Applying the Tar or Asphalt to the Crack.—The Emulsified asphalt is applied cold. It can be poured into the crack with a small pour-

ing can of not to exceed 2 gal. capacity. An ordinary water sprinkling can with the end of the spout broken off serves the purpose very well. Some of our men have used a coffee pot shaped vessel holding about 1½ gals. and insist that it is the most desirable pouring can that can be secured. It is desirable not to use too large a pouring can as this will make it more difficulty to apply just the right quantity of the bituminous material. For pouring the hot tar, it is necessary to have a well made pouring can so that it will not be injured by the heat melting the solder. However, owing to the fact that this grade of tar is not required to be heated to such a high temperature as the heavier grades of tar and asphalt, frequently the better grade of ordinary water sprinkling can, can be used satisfactorily for sometime before it is injured from the heat. If a heavy metal can is used such as to guarantee against injury from heat, it makes it more difficult for the pourer to put on just the right quantity of bituminous material and furthermore unnecessarily tires the workman because of the heavier load which he is all the time carrying. After the hot tar or asphalt is poured and before the covering is applied, the bituminous material may be uniformly distributed in the crack by drawing over it a small "V" shaped tool. This aids in putting the surplus material which is left at some places, into the places where the material has run down or there is a shortage because insufficient material was applied. The first time the crack is filled it will usually be necessary to immediately go over the crack a second time and refill those places where the bituminous material has all gone down into the crack. However, on refilling the cracks this second application will ordinarily not be required.

Perhaps no one thing is more important in this work than to guard against using an excess of the tar or asphalt. There should never be more of the bituminous material applied to the crack than will just fill the crack and extend over the edge of the concrete about ½ in., after traffic has "ironed it out." Experience and observation will soon teach one how much material to apply to secure these results. The bituminous material will rise up in the crack to some extent after the covering material is put on and this should be taken into account in pouring the proper amount of material. If an excess of the bituminous material is applied, successive applications will build up a ridge across the pavement which is quite as objectionable to traffic as the depression due to the spalling of the edges if the crack is left unfilled.

Covering Material.—Any fine grade of aggregate varying in size from the lower limit of a good concrete sand up to a grade of stone, slag or gravel which will go through a ½ in. circular opening may be used for covering. Even a bank sand that contains considerable more soil than permitted in good concrete sand has been used with very satisfactory results on the emulsified asphalt. With the tar, it is desirable to use a cleaner grade of material. While quite a range of size and quality of covering material seems to give very good results, it is desirable to secure a material ranging in size from ⅜ in. down to coarse sand. The covering material can be spread on the newly poured tar or asphalt from a bucket by hand or from a wheelbarrow with a shovel As much covering as will readily be absorbed by the newly applied tar or asphalt should be used. Although it may be a waste of material to put on an excess of the covering, the excess ordinarily will do no serious damage. It is desirable to guard against putting on too coarse a covering for small cracks and joints as this will add to building up a ridge.

Cracks and Joints Wider Than 1 In.—Where the cracks and joints are wider than 1 in. it is best to fill the cracks with bituminous mixture. For this purpose a graded aggregate of stone or slag ranging in size from ¾ in. to ⅛ in. should be used. Either the emulsified asphalt mentioned above, a cut back asphalt, or a cold mix tar may be used as the bituminous material to mix with the aggregate. Any one of the standard hot mix bituminous concrete can be used for this purpose. Usually, however, due to the small quantity of the mixture required it will be more economical to use one of the cold mix products. After the mixture is placed in the crack, a small amount of the same grade of hot tar or emulsified asphalt used in filling ordinary cracks should be applied so as to paint the edges of the crack. This will form a bond of the mix to the concrete and tightly seal up the crack.

We have attempted to fill large cracks with "quick hardening" concrete. It is necessary to reduce the size of the coarse aggregate (or omit it entirely) so that the mixture will go into the crack. Although I would not condemn this method of filling large cracks, I will say that so far we have not found it highly successful. The crack is usually not a stable thing. The same force that originally formed it is still working and causes it to vary. These forces break and crush up to some extent the thin sliver of new concrete. When a crack is filled in this way there usually results in a short while two cracks, one on either side of the filler. These, of course, can be filled and maintained as any other crack with bituminous material. We will carry on further experiments with this kind of work, hoping yet to

evolve a satisfactory method of filling large cracks with concrete.

Small Depressions in the Surface and Disintegrated Places Shallower than ¾ In.—Shallow depressions, or slightly disintegrated places in the surface which are, say shallower than ¾ in., may be filled by painting the depressed or disintegrated surface with either the emulsified asphalt or hot tar described above and coating same with fine aggregate ranging in size from ¾ in. to ¼ in. This produces what is ordinarily known as a "paint patch." Successive applications of the bituminous material and covering may be used to secure the desired thickness. Care must be taken not to use an excess of the bitumen as this may result in waves or rolls forming under traffic. If it is difficult to build up the desired thickness by this process, then the method next described should be used.

Surface Depressions deeper than ¾ In. But With Good Concrete Remaining That Will Serve as a Base for the Patch.—Such depressions should be filled with a bituminous concrete mixture made of a graded aggregate ranging in size from ⅛ in. up to 1¼ in. or not to exceed two-thirds the thickness of the hole to be filled. Although the mix made from ¾ in. to ⅛ in. material will ordinarily be satis factory, it is always desirable to use some coarser aggregate if the hole to be filled is of considerable size. It is very imperative that a graded aggregate ranging from the smallest size up be used in any mix for if the finer size is omitted, the mixture will be so open that it is liable to ravel and distintegrate under traffic. Emulsified asphalt AE-1 described above is satisfactory for use in making this mixture. A cut back tar (cold mix tar) may be also used. It will require 17 to 20 gals. of the bituminous material to 1 cu. yd. of mixture. This cold mix bituminous concrete should be leveled off and tamped into the depression with a heavy tamping iron taking all the precautions in securing a level surface that is ordinarily taken in spreading bituminous concrete either of the hot or cold mix variety. Where the depression is less than 1½ in. in depth, the old concrete surface should be painted with emulsified asphalt or a hot tar before the bituminous concrete is placed in the depression. It is not deemed necessary to paint the old surface where the depth to be filled is greater than this. If the surface of the mixture after it is spread, leveled and tamped has the appearance of being open due to insufficient fine aggregate in same, it should be given a seal coat of the tar or asphalt and covered with fine aggregate or coarse sand.

Portions of Slab Which Are Broken Through and Which Should Be Replaced With a Full Thickness of New Concrete.—Where the concrete slab is so broken that it will not be economical to patch it with bituminous material as described above, the old concrete should be removed and replaced with new concrete as described in the following paragraphs:

The old concrete can be removed by hand with picks, chisels and crow-bars. If any quantity of work is required it will be far more economical to use a paving breaker operated by a small portable air compressor in doing this work.

All the broken and disintegrated concrete should be removed and the old slab cut back until solid, rigid, concrete is reached which has on top a smooth and uniform surface. The top edge of the old concrete should be trimmed by

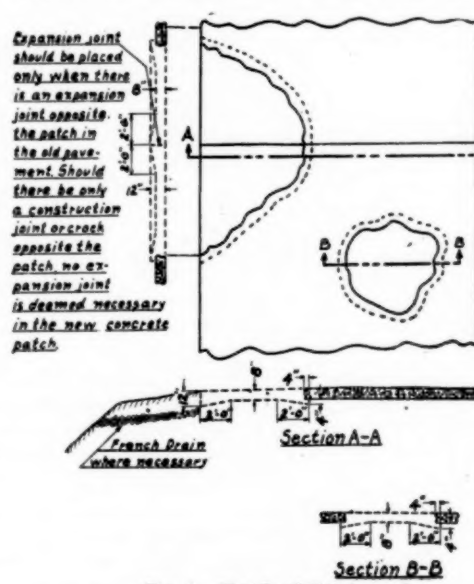


Fig. 1. Sketch of Patch

hand (with the use of hammer and chisel) to a uniform and vertical edge for a depth of about one inch below the top surface. The remainder of the vertical edge of the concrete should be left as rough as possible.

Preparing the Sub-Grades.—The sub-grade should usually be excavated to a greater depth than the original slab. At its junction with the old pavement the thickness of the new slab should be increased. The exact depth of the new concrete should depend upon the nature of the subsoil. The old concrete slab has failed for a reason. Quite frequently this reason will be found to be the soft clay sub-soil. Therefore, the thinnest depth of the new slab should usually be 2 in. to 4 in. deeper

than the old pavement. In spongy, clay soil, not only should the depth of the new slab be increased but it is also an added factor of safety to tamp into the sub-grade a 3 in. to 4 in. layer of cinders, gravel, or broken stone with an outlet to the side ditch, as shown in Section A-A in the design. (Fig. 1.) This will reduce capillary action in the clay and also help drain the surrounding sub-grade. The new concrete should extend back under the edge of the old slab several inches. (See Fig. 1.) The base of the projected edge of the old concrete should be thoroughly brushed to remove any spalled concrete or dirt.

Composition and Proportion of Concrete.—The concrete used in replacing the old concrete may be of a standard mix used in the building of modern concrete pavement. If such a mix is used, it would require closing the road from 25 to 28 days to protect it against traffic until it hardens. For this reason it is usually desirable to use a "quick hardening" concrete in order that the pavement may be open soon after the patch is laid. Frequently only small patches will be required and the added cost of the "quick hardening" concrete will not be a serious matter. This quick hardening concrete may be made by the use of Aluminite cement in the same proportion as ordinary concrete is made. Concrete made of Aluminite cement hardens sufficiently in 24 hours to permit it to be opened to traffic. **Quick hardening** concrete that may be opened to traffic in 2 days after laid may be made of ordinary Portland cement as described below.

Quick Hardening Concrete made of Ordinary Portland Cement.—Quick Hardening concrete made of ordinary Portland Cement depends for its early strength upon: (A) Richness of the mix, (b) Freedom from excess water, (c) Use of Ca Cl_2, (d) Comparatively high atmospheric temperature when curing, (e) Time of mixing, (f) Use of coarse sand and a properly graded aggregate. By taking advantage of all of the above five factors which affect the time of hardening, in one mixture, it is possible to make a concrete patch of ordinary Portland cement which can be opened to traffic two days after it is laid.

Richness of Mix.—The proportion of cement that should be used to secure a patch which can be opened to traffic after any number of days is shown in Table I. It will be observed from this table that to secure a patch which can be opened to traffic after two day's time, the proportion should be, 1 bag of cement, 0.5 cu. ft. sand, 1.9 cu ft. coarse aggregate, 2 lbs. Ca Cl_2, and only enough water to produce a slump in the concrete of about 1 in. Other proportions which should be used in making a patch that can be opened to traffic after any number of days are found in the table. This table is based, in a general way, on data furnished by Mr. Duff Abrams of Lewis Institute, Chicago, Illinois. The compressive strength of the mix when it is to be opened to traffic is about 3,000 lb. per square inch with an atmospheric temperature of 70 degrees F.

In order to secure the max strength of concrete, it is necessary to use a dry mix. (See Bulletin 1. Structural Material Research Laboratory. Lewis Institute, Chicago, for the strength of concrete with various percentages of water.) While a dryer concrete than a 1 in. slump will give greater strength it is impractical to make a patch from too dry a mix and hence a 1 in. slump is recommended as being the driest mix that it is practical to use.

Table I
PROPORTIONS

Days Patch Closed to Traffic (1)	Bags of Cement (2)	Cu. Ft. of Sand (0—¼") (3)	Cu Ft. of Coarse Aggregate (½"—2½") (4)	Lbs. $CaCl_2$ or Qts of "Standard Solution" (5)	Water Add enough to produce Slump given below (6)	Bags of Cement per Cu. Yd. of Concrete (7)	Remarks (8)
2	1	0.5	1.9	2	1"	11.8	This mixture to be used for small patches that are to be opened to traffic at the earliest date possible. Atmospheric temperature should average about 60° F.
3	1	0.4	2.1	2	1"	11.2	
5	1	1.0	2.7	2	1½"	8.4	
12	1	1.3	3.0	2	1½"	7.6	Standard Mix to be used where closing road to traffic is not an important item and where large areas are to be patched.
15	1	2.0	3.0	2	1½"	6.8	
21	1	2.0	3.0	No $CaCl_2$	2½"	6.8	

(5) This "Standard Solution" is made by dissolving commercial $CaCl_2$ in water at the rate of one (1) pound to enough water to produce one (1) quart of solution. The pure $CaCl_2$ should never be added direct to the drum of the mixer. The "Standard Solution" should be added to the water just before it is put into the drum. See instructions under Calcium Chloride.

(6) Standard Slump Test. Fill with concrete a metal form shaped as a frustum of a cone. Form should be 12 in. high with a 4 in. top diameter and 8 in. base diameter. Set the form on a level surface and as the concrete is put in the form, tamp lightly with a rod until a slight film of mortar appears on the surface. Then remove the form and immediately note the settlement or slump of the concrete which is a measure of its consistency.

Use of Calcium Chloride.—The addition of calcium chloride to concrete quickens the time of hardening. (See Bulletin 12 of the above Laboratory.) The addition of 2 lbs. of Ca Cl2 per sack of cement adds about 40 per cent to the strength of concrete two days old. Hence, the value of the Ca Cl_2 in a quick hardening concrete. While 3 lb. of Ca Cl_2 to a sack of cement seems to give a maximum strength, the additional strength of 3 lb. over 2 lb. is

small. Also, more than 3 lb. starts to reduce the strength. Hence, it is deemed advisable to use about 2 per cent $Ca\ Cl_2$ in making the quick hardening concrete. The calcium chloride should not be added directly to the concrete but should be made in the form of a "standard solution" of about 2 lb. of calcium chloride to 2 qts. of water and this solution put in the drum of the mixer with the rest of the mixing water.

High Atmospheric Temperature—To secure quick hardening concrete of ordinary Portland cement, advantage must be taken of the accelerated hardening due to comparatively high atmospheric temperatures. For instance concrete cured at 40° F. will have only about 70 per cent of the strength if cured at 70° F. when cured at 80° F. it will have about 105 percent of its strength if cured at 70° F.; etc.

Since the strength of concrete is increased by increasing time of the mix up to a certain limit, it is desirable to take advantage of this in producing a quick hardening concrete by extending the time of mix to at least 2 minutes.

Properly Graded Aggregate & Coarse Sand. A course sand that meets the specification for good concrete work will produce a concrete that is stronger in its early stages than the concrete produced from the finer sand. (See Bulletin 9, Structural Materials Research Laboratory.) A properly graded aggregate also adds to the strength of concrete. Hence the extreme importance in producing this "quick hardening" concrete of having a well graded aggregate and a good quality of course sand.

Mixing Concrete Only **machine mixed** con—crete should be used. In practice, it is almost impossible to produce a uniformly maximum strenth concrete, which is very imperative in repair work, if one depends on hand mixing. The usual time specified for mixing ordinary concrete in a mixer is 1 minute. However, tests show that the strength of a dry mix may be increased as much as 10 percent by mixing 1½ minutes instead of 1 minute and the strength is slightly increased by extending the time to 5 or 10 minutes. In repair work where there is used a small mixer which will generally be less efficient than the big paving mixer, and where a dry mix is required for a max strength and quick hardening concrete, the time for mixing might well be placed at not less than 2 minutes. Where it is extremely important that a high strength be secured at the earliest date possible and only small quantities of concrete are required, it should be mixed 5 minutes. This increased time of mixing will also make the finishing easier.

Placing and Finishing Concrete—Concrete should be shoveled in place and thoroughly tamped. The secret of the early strength of the concrete will largely lie in a comparatively dry mix hammered in place. A 10 lb. concrete tamper can be used for much of this work. A thin edged tamper having a face, say, 1 in. x 4 in. should be available for tamping in narrow openings and along the edge underneath the old slab.

The concrete patch should be finished with a straight edge, template, and a wood float, to a regular and uniform surface to fit the crown and edge of the surface of the old pavement. The straight edge should be used longitudinally on the new concrete where the patch is not too long to do so. Where a full width of pavement is being replaced for a length greater than the length of the straight edge. a template cut to the proper crown of the road should be used. This template can be used both as a cutting edge and tamper to produce a uniform surface. At either end of such a patch a straight edge should be used longitudinally to insure a proper and uniform junction of the new concrete with the old pavement.

With a dry mix and quick hardening mix it will be necessary to finish the surface before the mix stiffens to any appreciable extent. Too long a delay in finishing may make it impossible to make a good finish and will greatly add to the cost of the work.

Curing Concrete Patch.—The great advantages of properly curing concrete are so well known that they hardly need enumerating here. The concrete containing $Ca\ Cl_2$ does not need the protection which ordinary concrete needs. However, it is best to furnish protection to the concrete with a damp cover for one-half the time the new patch is protected against traffic.

Kind of Patch to Make.—There will be places in the pavement where it will be difficult to decide whether to make a surface patch with bituminous concrete or whether to cut away the old concrete and replace it with new concrete. Careful study of which method to use, taking into account all the valuable factors affecting the most economical methods, should be made. The men in the field will naturally insist on making that kind of a patch with which they are most familiar. Their customs and habits will guide them almost entirely. Because of their skill in making one kind of a patch and their ignorance of another, it may be even economical at times to permit them to make their favorite patch even though it would not be the most economiscal, if another kind of patch were properly made. This could only be true, however, if a very limited number of such patches were required.

It is believed that the foreman should be taught how to make a good cement concrete

patch as well as a Bituminous concrete patch. These two classes of work should not be too much for his mind to master. Perhaps no one thing in the Construction world is so universally used as concrete and hence every man who associates himself with such work should master the principals involved in making good concrete.

It should hardly be necessary to warn here against letting some "old timer" make concrete patches after the old sidewalk method by putting in a dry base and letting it partly set after which it is finished with a rich mix of sand and cement. The general Supervisor of such work should stop this method before it gets established. Concrete of good quality and the same quality should be used from the bottom up.

What the 1925 California Traffic Census Showed

The first general traffic count on California highways was taken in 1920 by the U. S. Bureau of Public Roads. Two years later this bureau in cooperation with the state highway commission and several counties renewed and expanded the census. In 1924 the highway commission made a count at about 300 stations in the state system. The latest census of traffic was taken from July 12 to 18 in 1925 for 16 hours daily. Some interesting information regarding this is given in California Highways by G. R. Winslow, Maintenance Engineer of the state highway commission.

Both in 1924 and 1925, the counts were made by the maintenance forces in so far as they could be spared for the work. Records were kept on specially prepared forms so cross-ruled that the horizontal lines represented hours of the day, and the vertical columns types of vehicles. At stations where vehicles were too numerous to permit the making of a check mark record, mechanical counters were used for passenger cars, and, for this type, only the total for each hour was entered on the sheet. Trucks, trailers, and busses, however, were recorded by the mark and tally system.

Studies have been made of the 1920 and 1922 censuses, particularly with reference to the hourly variation, the daily variation within the week, and the seasonal variation. In general, traffic between 6 a. m. and 10 p. m. amounts to substantially 92 per cent of the traffic for the twenty-four hours of the day. Sunday counts average about 25 per cent of the traffic for the entire week and Saturday traffic is about 16 per cent. The remaining days of the week are practically uniform. Summer traffic is about twice that of winter.

Applying these factors to the records of the 103 stations which were identical in the counts of 1920, 1922, 1924 and 1925, there is indicated an increase in traffic on state highways in four years of 93 per cent. Growth of traffic has been continuous throughout this period, but the percentage of increase was not as rapid in 1925 as in the earlier years.

The heaviest traffic anywhere on the state highway system during the period of the 1925 count was at Santa Monica on Route 60. The number of vehicles passing that station on Sunday, July 12th, between the hours of 6 a. m. and 10 p. m., was 25,661, and the average daily count between these hours for the entire week was 17,758. The traffic on Sunday at the easterly city limits of Los Angeles was 23,806, and less than at the easterly city limits of Los Angeles. At several places between San Francisco and San Jose, on Route 2, the Sunday traffic was over 22,000 and the average for the week over 11,000.

It is interesting to note that at the north city limits of San Jose, on Route 2, maximum traffic was recorded on Saturday when the count reached 22,623. The average for the week at this station was 20,153.

In the interior of the state, traffic on Route 4, at the north limits of Fresno, on Sunday was 11,167 with an average for the week of 7,715. The heaviest traffic in the Sacramento Valley was at the north city limits of Sacramento, on Route 3. The Sunday count at this point was 10,140, and the average for the week 9,767.

The heaviest traffic at an interestate connection was on the Pacific Highway at the Oregon line. The Sunday traffic was 1,246 and the average for the week 1,088 at this point.

To determine the traffic density, the average number of vehicles between the two stations was multiplied by the miles between the stations, and the sum of such products for any given road was divided by the length of the road. The traffic density for the system, or for any specific section, multiplied by the miles gives the average vehicle-miles traveled per day.

Assuming the traffic between 6 a. m. and 10 p. m. to be 92 per cent of that for the whole day, and that the annual traffic varies from five times the July traffic, in recreational areas, to eleven times the July traffic at city boundaries, we have over 2,120,000,000 vehicle-miles as the total annual movement on state highways. (The census covered 4,840 miles of the state highway system, including all important traffic arteries.)

Traction Company to Operate Taxicabs.—The City Council of Philadelphia has granted the Philadelphia Rapid Transit Co. the authority to operate taxicabs.

Bituminous Macadam and Surface Treatment

Some Suggestions Given in Paper Presented at Twelfth Annual Road School, Purdue University

By EARL B. LOCKRIDGE
District Engineer, Indiana State Highway Commission

Bituminous macadam, also known as penetration macadam because of its style of construction, is probably done an injustice more frequently than most of any other type of pavement through inferior construction, attempts to construct too cheaply, and salvaging of old gravel and stone surfaces that are not worthy of the consideration given them.

Major Requirements of Construction.—I will not attempt in this paper to set out a specification or standard of construction, but will say that the construction should be along approved standard lines, some of the major requirements of which are: Sufficient right-of-way on which to construct a satisfactory roadbed, which roadbed should be true to grade and alignment, built up of substantial material thoroughly drained and compacted, and on which should be constructed a waterbound macadam base course and top course preferably 1 ft. wider than is contemplated to build the bituminous macadam top. The quantity and quality of material that combines to make this pavement is of the utmost importance, yet no less important is the skill and judgment of workmen who serve to assemble, rake, spread, penetrate, roll and mould these ingredients into the final compacted surface on which you travel. Weather conditions are a factor and must always be taken into account, low temperatures and dampness being especially objectionable.

Unlike some types of pavement wherein costly mechanical appliances have been provided, which, if operated by honest hands, will do uniformly good work, the degree of refinement and perfection of a bituminous macadam job depends to a large extent upon the skill of workmen and the knowledge and alertness of inspector in charge.

Surface Treatment of Bituminous Macadam.—Having once secured a properly constructed pavement of the type under discussion, maintenance is an easy task and really becomes a pleasure. It is well to surface treat a bituminous macadam pavement the first and probably second year after construction, and thereafter as surface conditions will require. Original construction may be of either tar or asphalt product and the surface treatment may alternate, using either of the materials differing from the original construction or previous surface treatment as occasion warrants. The lighter tar being more pliable, has been found to be quite practical for first treatment after construction. The asphalt treatment will ordinarily wear longer and not want to be repeated as often.

It is necessary to make a study of our surface and the traffic that it is to carry in order to determine when to surface treat and the quantity and grade of material to use. Those roads of which I have had personal observation, have had treatments ranging from ⅓ gal. of bituminous material per square yard of surface, when first taken hold of by state in bad condition, to as low as 1/6 gal. per square yard of surface when found in good condition, treatments coming about every other year.

Application of Bituminous Material.—Before applying bituminous material, the surface to be treated must be thoroughly cleaned and dry, and traffic should be kept from it during application, both for its own protection and the good of the work, until after covering material has been added. If not creating too much of a hardship, it is well that the road be closed for one or two days, though in actual practice I suspect there are more cases where traffic is warned of fresh bituminous materials and then allowed to pursue its own course uninterrupted than there are where the road being treated is really closed. The bituminous material should be uniformly applied to proper temperature from an approved pressure distributor.

It is essential and imperative that covering material be applied without delay after a surface has been treated, said covering to consist of stone, slag or gravel, thoroughly clean and graded closely between ¼ and ¾ in. in size. An excess of the larger size is preferable when treating an open, comparatively rough surface, while the smaller size is desirable when you have a surface that is well closed and smooth.

The quantity of covering material to be used per square yard of surface depends upon the condition of surface you are dealing with, the

grade of tar of asphalt being applied, and the amount that is applied per square yard of surface.

For estimate purposes, where tar is used it might be said that 54 lb. of stone to the gallon or 1 cu. yd. to 46 gal. and where asphalt is used 88 lb. of stone to the gallon or 1 cu. yd. to 28 gal. of the bituminous material are about right. The same gallonage would prevail per cubic yard of slag or gravel.

The covering material should always be spread direct from dump trucks as they will spread same more uniformly and cheaper than can possibly be done by hand from piles or conveyance not equipped with dump. A bituminous macadam pavement properly constructed will improve under traffic and maintenance, riding smoother year after year.

So far I have dealt with the ideal, assuming a bituminous macadam road that has been properly constructed and followed up with maintenance as same should be.

Reconstruction of 21 Miles of Lincoln Highway.—Unfortunately the ideal is too often a dream and in real practice we have something entirely different. It has been my lot to have charge of the Lincoln highway through Porter and Laporte Counties where the state highway commission through its maintenance department has reconstructed the entire distance of 21 miles between the cities of Valparaiso and Laporte. Within this distance there were many vexing things to handle, not the least of which was matter of securing right-of-way sufficient on which to operate and construct creditable pavement. There were drainage pipes and small concrete culverts to extend, new alignments requiring fills of half or the entire width of roadbed, narrow grades to be widened, and worst of all a satisfactory base course to be prepared on which to place the bituminous top.

Parts of the original bed has been well constructed as a waterbound macadam pavement (though with excess crown) to the width of 10 and 12 ft. and later surface treated, then parts allowed to lapse back into an ordinary stone road through failure to follow up with subsequent treatments.

Other parts of this road consisted of a conglomeration of stone slag, gravel, and cinders varying in width, depth, and quality of material until it was difficult to know just what additional new material should be added in way of preparing suitable base without being extravagant.

The outer 3 ft. on either side of an 18 ft. strip had to be built up throughout and a light waterbound course was necessary over the entire top, in most cases, to reduce the crown of old surface if not required to give additional strength of base. At a few points it was found necessary to alter the grade because of abrupt changes, but in the main every bit of the old road was salvaged and stands today as a part of the new construction, the taxpayer still realizing from the original investment in roadbed, stone, and drainage structures.

This is the feature that should appeal to the taxpayer in this style of construction, in that nothing is wasted or destroyed that already exists. Bituminous macadam is one of the few types of pavement that meets those conditions; but as stated in the second paragraph of this paper, is frequently done an injustice by trying to salvage surfaces that are not laid on proper grade or alignment, or that have not the quality, depth or width of material thought to exist.

Repairs to Faulty Construction.—Having misjudged strength of base or through other causes gotten a faulty pavement, the matter of maintenance or repair becomes a more difficult problem. If pavement breaks near the edges it indicates weak base, poorly compacted fill in widening roadbed, or lack of rolling or perhaps insufficient drainage. There may be a spot that shows signs of ravelling or rutting due to insufficient bituminous material, or fact that same failed to penetrate because of dirty surface closed too thightly, or saturated with water. Whatever the cause may be it is well that those who have in charge the matter of making repairs should at first attempt to diagnose the case and then proceed to remedy both defect and cause in an intelligent manner, using one of the several grades of tar or asphalt that is best adapted to the character of repairs to be made.

Patching Bituminous Macadam. — Bituminous macadam surfaces can always be patched without seriously interfering with traffic. Patches are made of premixed cold or heated materials, or by penetration method if of sufficient size to warrant same and may be either hand tamped or rolled into place. More frequently the cold mix materials are used (Tar T. C. M. or Emulsified Asphalt) and the patches being small and far apart, are compacted with hand tamp. Again, the matter of refinement to be attained in patching or eliminating a construction defect in a bituminous macadam surface, is entirely within the hands of those performing the task. A skilled man with mechanical eye will feather out his work until you cannot tell where the patch is except by color and not at all after the next surface treatment has been applied.

The size of aggregate to be used should vary some with the depth of patch or repairs that are being made. A deep patch might be made with all fine aggregate; however, it would be more practical if the coarser sizes of stone

were used, and with the thin layer that feathers out to nothing it is obvious that the smaller aggregate will have to be used. There is a small amount of settlement due to the mixed material compacting under tamp, also under traffic later, this varying with depth applied, but that feature is readily mastered by the observing workman and proper allowance made for same.

Where it becomes necessary to make repairs because of raveling or desire to eliminate a low spot due to faulty construction, the hole or surface is thoroughly swept and cleaned of all loose or foreign matter and painted lightly with the bituminous material of which patch is being made. This insures bonding of the old and new and helps to seal against moisture getting under the patch. Likewise the top should be sealed and made more dense by brushing a thin coat of the bituminous material over same and applying some fine stone or coarse sand. It is very necessary to have a dry surface and dry stone or other material for aggregate when using any of the bituminous repair materials except Emulsified asphalt. This material may be used on damp surface with damp stone, the only difference being that you mix less water direct with your emulsified asphalt under those conditions.

Surface Treatment.—Surface treatment road work consists of two distinct types, that following the construction of a bituminous macadam pavement as heretofore referred to and that wherein the first bituminous material used consists of a treatment direct to the surface of a waterbound macadam, stone or gravel road. A well constructed waterbound macadam road that is not burdened with excessive traffic can be treated, made dustless, less costly in maintenance and frequently pass as a bituminous macadam job at a very light cost. To get best results, if known when constructing the water bound macadam that a bituminous treatment is to be given, it is well to hold back on the screenings, so as to leave the top stone exposed, making it possible for the bituminous material to get to more of the surface of this coarse aggregate.

A waterbound surface must be thoroughly swept and cleaned of all foreign matter before treatment. Also the surface must be dry and temperature of atmosphere aoove 45° F., temperature of bituminous material to be as specified for grade used and to be uniformly applied from an approved type of pressure distributor. Ordinarily on this type of surface treatment work, the gallonage per square yard of surface is much greater than used on bituminous macadam maintenance, requiring same to be put on in 2 or more applications. It should never be applied at such rate as will permit of bituminous material running off the edges of metal and wasting.

Treatment of Stone and Gravel Surfaces.—The same principles involved in treating bituminous macadam and waterbound macadam also prevail in the treatment of stone and gravel surfaces. Namely: they should be dry, clean and free from dust and foreign matter, presenting a well compacted surface wherein the larger size of clean stone or gravel are exposed, such that the bituminous material can get to the surface of the coarser aggregate. Under proper conditions, the first application of say 0.3 gal. per square yard will entirely disappear from the surface, penetrating to a greater or less depth in the aggregate in the road. After this treatment has been given sufficient time (perhaps 24 hours) in which to penetrate and get set, additional treatment or treatments follow until the required amount of bituminous material has been used, when it is covered with stone, slag, or gravel similar to manner heretofore mentioned in connection with bituminous macadam surface treatment, the quantity depending upon condition of surface and amount of excess bituminous material that remains to be absorbed.

It may be necessary to give a very light application of covering material after each application of bituminous material to keep same from flowing to edges of metal in case of smooth surface and excess crown, also to keep from picking up when making next distribution. After the last application and all covering material is in place, the surface should be dragged repeatedly until every chip or pebble is thoroughly coated and the surface becomes tacky.

Traffic should be kept from the surface throughout process of treatment and for about two days after dragging operations have ceased, during which time a curing effect takes place leaving a dry dustless surface that will stand up under quite heavy traffic.

This is very cheap and practical maintenance when properly carried out under favorable conditions, though I fear it is too often tried as sort of an experiment under adverse conditions, thereby resulting in the abominal pot holes and abrupt breaks in surface such as we frequently find on heavy traveled streets through the smaller towns where an attempt has been made to get away from the dust, regardless of the kind of surface to be treated, the grade of material to be used or the manner of applying it.

British Road Expenditures.—It is estimated that $83,000,000 will be expended on roads in Great Britain during the fiscal year ending March 31, 1927.

Corrugations in Roads

Their Causes and British Devices for Their Examination Described in Roads and Road Construction, London

By PERCY E. SPIELMANN

There have been many suggestions as to the immediate cause of the formation of waves in road surfaces and, probably, most of them are sound but of varying importance. None, however, can be said to be the cause because, almost certainly, there is always a combination of influences that are active in any particular case. These influences produce their effects in all kinds of road except, I suppose, in concrete roads; but to say, as has actually been said, that the steam roller is not responsible because waves occur in wood paving which is never rolled, is a false argument, and one that is to be met with in a certain book where it would not be expected.

Suggested Causes.—The following causes that have been suggested from time to time, as leading to the production of waves in macadam of various kinds and in bituminous surfaces, may be shortly reviewed, even though they may have been referred to in print elsewhere.

1. Failure of the Foundation will cause the formation of hollows on the surface which will set traffic bouncing so as ultimately to produce a series of depressions and ridges.

2. Irregularity of the Surface of the Foundation will cause unequal vertical resistance to the traffic, through variation of thickness and, therefore, of resilience in the road surface carrying the traffic; inequalities will result during subsequent consolidations.

3—5. Lack of Compaction, or Too Soft Bitumen or Tar, or Faulty Composition of the Road Mixture will all permit of horizontal movement and, therefore, of puckering of the surface.

6. Careless Rolling will cause irregular consolidation of the top layer which may become accentuated by traffic subsequently bouncing over it.

7. Lack of Union with the Foundation, or lower course, will allow of slipping of the top layer.

8. Sudden Change of Speed or Direction of power vehicles will tend to scoop or shove the surface into mounds and hollows.

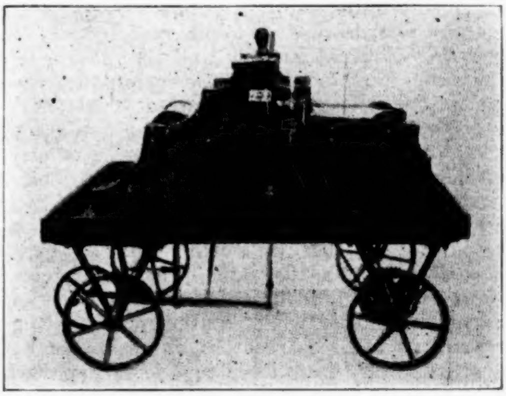
9. Centrifugal Action of traffic when rounding curves will behave similarly.

10. Badly-placed Manhole Covers, etc., and

11. The Extra Height of Subsequent Patches will also start traffic oscillating vertically.

Thus it will be seen that there are two directions of movements that can be caused to a road surface, either or both of which may lead to the formation of waves; a vertical squeezing action resulting from the hammering by bouncing traffic, and a horizontal one of pushing and sliding. Of these two the first may be of less importance because the weight and period of the vertically oscillating units of traffic are so various that there will be a tendency by each to obliterate the incipient effects produced by the other.

The second action, on the contrary, is the more dangerous because once shifting has begun—with or without the accompaniment of the first-named movement and its result—there is every reason for it to continue and become cumulatively harmful. The height and thickness of the ridges increase with the time, or are drawn into "V"'s, and the hollows become progressively thinner till the binder course or foundation is exposed.



Horne's Corrugmeter

Principles Underlying Formation of Waves.—I have not seen in any textbook on road matters attention being given to the principles underlying the formation of waves, yet this was demonstrated and explained as far back as 1914.

Dr. Vaughan Cornish, as a result of his study of wave formation in many materials, found that in incompletely compacted solids the determining condition was for the material, under the influence of a moving object, to shift and at the same time to become consolidated into a mass harder than it was in its initial state. The moving object would then ride over the obstacle thus formed and plough into a softer material ahead of it, which would then become consolidated in its turn and so form a new wave.

This is the way in which a toboggan-run becomes wavy after a time and why waves can

similarly be produced in a sand containing a limited amount of water.

In the case of a bituminous carpet mixture the phenomenon is undoubtedly of the same nature, but it is, at the same time, a little more complicated: either consolidation occurs through differential movements of some of the mineral aggregate relative to the cementing material; or else the whole becomes denser through the collapse, under the combined influence of pressure and movement, of the air spaces (the "voids")—perhaps both changes occur at the same time.

Devices For Recording Outline of Road Surface.—There can be no doubt concerning the importance of the exact study of the causes of wave formation in individual cases and their co-ordination with nature and composition of the road surface and the foundations, the prevailing temperature and the rapidity of its change, and the quantity and the nature of the traffic that is borne. The information required for such an investigation is not only that concerning the height of the waves and the distance apart of their crests, but also of their shape and the rate of change of their position. A number of ingenious instruments have been devised for recording the outline of a road surface that are worth recalling. They are all based on the same principle: a carriage of some kind bears a drum or band of paper and, either whilst stationary or during travel, a tracing is recorded on the paper by a pencil which is attached to a lever operated by a wheel that is in contact with the surface under examination.

The most recent instrument is probably the "Corrugmeter" of B. Horne, of Chipping Norton.

The carriage, when moving, unrolls a band of paper at a rate proportional to the distance of travel—2 ft. 6 ins. of paper to 10 ft. of roadway—and on this is inscribed the outline of the road surface by a stylus connected with a trailing wheel. Mr. Horne writes: "It will be observed that these sections are comparable to the general surface of the road, and not to a horizontal datum line; that is to say, the result will be similar to, but more accurate than, that obtained by gauging from the surface of the road to a straight edge."

Mr. Leeming, in his book on "Road Engineering" (1924), refers to a very simple instrument of his own devising, which consists of a straight edge, placed on the ground, and provided with a slider, guided by the straight edge, and resting on a wheel; it is provided, also, with a pencil which inscribes an outline of the surface of the road on a strip of paper fixed along the side of the straight edge.

In "Modern Road Construction" (1920), Mr. Wood describes the "Viagraph," of Mr. J. Brown, F. R. S. This consists of a kind of sledge formed of two straight edges, parallel to one another, which is drawn along the road. The pencil is connected with a traveling wheel and inscribes on a drum that is driven by clockwork. There is an arrangement whereby the upward and downward motions of the wheel are summed, whereby numerical value is given to the degree of inequality of the road surface.

One of the earliest instruments is that of Col. R. E. Crompton, R. E. This is very like the latter and somewhat simplier instrument of Mr. Leeming's, but is provided with wheels, and the traveling pencil is moved by a wire that passes over a wheel above the instrument that is actuated by hand.

In all these instruments there is, in my opinion, and contrary to that of Mr. Horne, one important fallacy which underlies the prin-

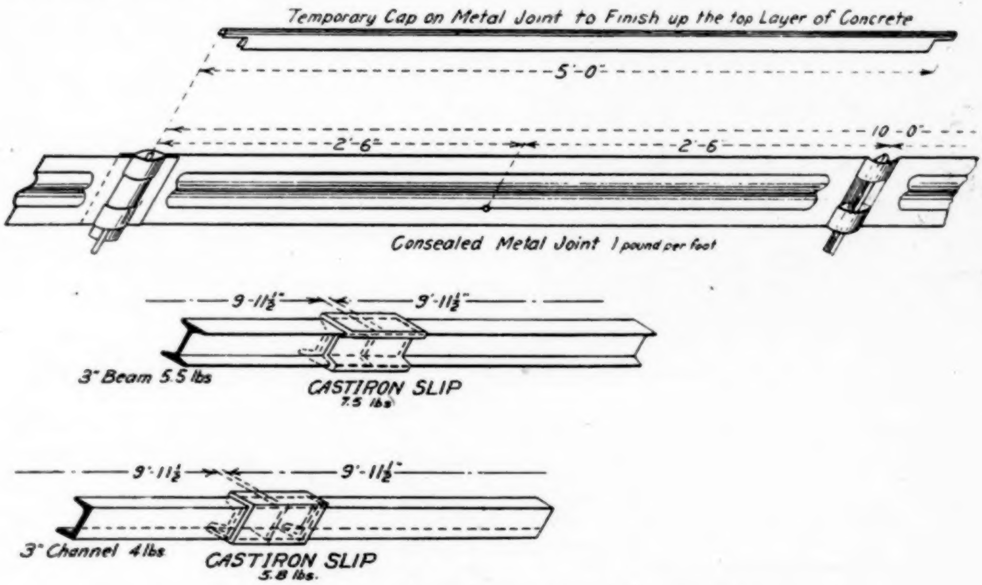
Leeming's Instrument For Measuring Corrugations

ciple on which they act and partially vitiates the results obtained. This is, that the records of the road surface are taken relative to the surface itself and not to an independent and permanent position of reference. If, for the purpose of close study, a second record be taken at a later date and the surface has changed, the new tracing will be taken relative to the new surface. Not only will the movement of the pencil be different but the level of the paper will have changed, because the machine carrying it will now be resting on a changed road surface—one that is either vertically lower or of a different inclination. Accurate and comparable results can only be obtained if the position of the drum be maintained continuously, permanently, and absolutely at the same level. This is very difficult to effect but it is not impossible, and it is as worthy of attainment as is the best accuracy.

Uniform Strength in Concrete Pavement.—Stress measurements made by the U. S. Bureau of Public Roads on concrete pavements of the thickened edge design in the states of Illinois and Pennsylvania indicate that uniform strength is obtained where the thickness of the central portion of the pavement is approximately seven-tenths of the edge thickness, providing that a longitudinal center joint of a type capable of transferring load is used. Otherwise there would have to be a provision for increasing the strength of the interior edge of the half slab.

Joints for Concrete Roads

A new expansion and contraction joint for concrete roads has been invented by Paul Kuhne, La Crosse Ave., The Bronx, Niles Center, Illinois. It consists of a sheet metal strip placed lengthwise in the center of the road. The strip is provided with loops to receive pins for setting the strip. S-sections are formed between the loops to stiffen the metal strip and to insert the concrete on both sides. The metal strips are connected together by lapping over into the loops and are wedged together with wedges of soft wood, allowing the sheet metal strips to expand and contract.



Sketch Showing Concealed Metal Joint and Concrete Reinforcement

Not all the cracks in concrete roads are due to insufficient expansion and contraction joints; they are also due to an uneven support of the concrete slab on the road beds because the partly filled in grading settles making hollow places. To carry the heavy truck loads over a larger surface of the uneven road bed the tie rods are intended to form with steel beams and channels a solid body. Mr. Kuhne provides steel bars connected with cast iron slips or sleeves to allow the steel to expand and contract. The tie rods for first half of the road are connected to the metal joint at the center, using nuts with washers to fit on both sides. Turnbuckles connect the tie rods of the other half of the road after the first half is finished. The working joints in the concrete are placed every 50 ft. and have two sheets of asphalt saturated felt. The expansion and contraction joints of the steel are to be placed every 10 ft. apart.

The Cuban Central Highway

It is expected that final surveys for the Cuban Central Highway will be ready by July 10. Continued difficulties in connection with the method of financing the construction, or decision as to whether outside financing will be neecssary at all, have prevented any definite announcements by the government as to the way contracts will be awarded, or the time that bids will be called for. Several proposals have been made the government lately, but the attitude of the administration continues to be against accepting any which will involve a foreign loan. Full duties will be paid upon all materials and equipment imported for the Central Highway and contractors must include this outlay in bids presented. Granite blocks, it has been decided, will be employed over a total extension of about 150 kilometers and the preference of the government is to pave the remaining 870 kilometers in bituminous concrete on a cement concrete base. Provision will be made, however, in the specifications for manufacturers to bid on any special or patented payments, as long as a five-year guarantee is made. The Department of Public Works estimates on the basis of previous jobs and other data, but not actual surveys, that the total cost of the highway will average $56,570 per kilometer.

Grading on Iowa Roads.—The total grading in 1925 from primary roads funds in Iowa was 484.7 miles requiring the handling of 5,904,124 sq. yds.

Crosswise Trucks Convert Building Mixer Into End Discharge Alley Paver

New cross-wise trucks for converting a side discharger mixer into an end discharge machine have been brought out by the American Cement Machine Co., Inc., manufacturers of the Boss mixer, Keokuk, Ia. The accompanying illustration shows a Boss One-Two bagger

Mixer on Cross-Wise Truck Attachment on Alley Paving Job

mixer mounted on cross-wise trucks with a short swinging chute on an alley paving job for the Kelly Construction Co., St. Joseph, Mo. This machine handles two sacks 1:2:4 mix or 10 cu. ft. mixed and is stated to give a daily capacity of over 100 cu. yd. The machine being built of steel is stated to weigh no more than an ordinary one-sack mixer and by merely slipping wheels off, special axles with spindles are slipped on axles and wheels then put on the cross spindles converting the mixer into an end-discharging machine. One of the axles has a pivot arrangement for turning corners when towing. It is but a 10-minute job to remove attachment if side discharge is wanted.

New Trade Publications

The following trade publications of interest to highway officials, engineers and contractors have been issued recently. Copies of them can be obtained by addressing the firms mentioned:

Gratings and Treads.—The Grating Co. of America,, Pittsburg, Pa., has issued a circular relating to its trilock gratings and treads for sidewalks, floors, subways, etc., Tables giving safe loads are included.

Conveyors.—A circular illustrating and describing its conveyor system for handling sand, gravel, stone, coal, coke or other loose material has been issued by the Galion Mfg. Co., Galion, O. It contains sketches of possible installation together with descriptions of the bucket hoists, skip hoists.

Tablets, Name Plates, Castings.—A catalog illustrating and describing bronze tablets and name plates for use on bridges, waterworks, buildings, etc., has been issued by the Egyptian Iron Works, Murphysboro, Ill. The catalog also includes the manhole covers, grates, inlets, catchbasins covers and other municipal castings made by the company.

Sand and Gravel Handling Buckets.—The Hayward Co., 50 Church St., New York City. has issued a bulletin covering the use of Hayward buckets and other Hayward equipment in the mining or digging and distribution of sand and gravel. Illustrations and descriptions are given of the use of buckets with locomotive cranes, with crawler cranes, truck cranes, derricks and cableways. Numerous illustrations also are included of special applications of the buckets.

Cranes.—A bulletin illustrating and describing its models T and E convertible cranes has just been issued by the Orton Crane & Shovel Co., 608 S. Dearborn St., Chicago, Ill. It contains numerous illustrations of the cranes in various construction operations, together with full descriptions of the various features of the crane. General specifications and working dimensions also are given.

Crawlers for Fordsons.—Details of construction specifications and uses of Trackson full-crawlers are described and illustrated in a new 8-page 8½x11 bulletin of the Full-Crawler Co., 501 Clinton St., Milwaukee, Wis. The bulletin explains and shows by sketches and photographs the construction of various parts of the Trackson Full-Crawler. Sixteen action photographs show the Trackson-Fordson performing various types of work which include fresno work, backfilling, industrial uses, land clearing, road building and maintenance, excavating, power scoop work, cemetery and golf course work, snow removal, subdivision and orchard work and harvesting.

Truck Body Hoist.—The operation and construction of the Heil twin cylinder hoist are very clearly brought out in a bulletin just issued by The Heil Co., Milwaukee, Wis. Numerous illustrations are given of the various features of the hoist and its applications to the truck body.

Industrial Notes

The Chain Belt Co., manufacturers of Rex Mixers and pavers, Milwaukee, Wis., announces the appointment of the Contractors Equipment Co., of Florida, as distributors on the entire East Coast, and part of the West Coast, for the entire line of Rex concrete mixers and pavers. The Contractors Equipment Co., has its headquarters at 2315 No. Miami Ave., Miami, Fla., and also branches at Jacksonville, and West Palm Beach. Two other new distributors are E. F. Craven of Greensboro, N. C., and J. F. Francis, of San Antonio, Texas. These two companies will also carry the Rex 55 and 75, 14S high speed mixers and new 27E pavers.

A Milton Buck has joined the sales force of the Bridgeport Brass Co., Bridgeport, Conn. Mr. Buck will live in Washington, covering Washington, D. C., and the states of Maryland, Virginia, and West Virginia, specializing on sales of Bridgeport-Keating flush valves and plumrite brass pipe.

The Harley Davidson Motor Co., of Milwaukee, Wis., manufacturers of motor cycles, has adopted for its new, improved and highly economical type of machine the "Ricardo" type, combustion chamber. They are manufacturing this under license from the Waukesha Motor Co., Waukesha, Wis., builders of heavy duty engines for over twenty years. The new single cylinder Davidson motor cycle is reported to make 80 miles per gallon.

The T. L. Smith Co., Milwaukee, Wis., announces the appointment of The Arizona Tractor & Equipment Co., of Phoenix as distributors for the state of Arizona. The full Smith line of tilting, non-tilting and paving mixers will be represented and a complete stock of mixers and repair parts will be carried.

The phenomenal growth of sales of Timken bearings for industrial uses has brought about the promotion of G. W. Curtis from industrial equipment engineer to district manager of sales, Industrial Division for the Milwaukee territory. Mr. Curtis will work with R. W. Ballentine, who previously handled this territory. S. M. Weckstein succeeds Mr. Curtis as industrial equipment engineer. Mr. Weckstein has been notably successful in developing Timken bearing applications for precision work in machine tools and high speed applications. G. W. Richards and A. R. Spicacci are appointed assistant industrial equipment engineers to assist Mr. Weckstein.